NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C.

CONTRACTOR FINAL REPORT

TEST # 129

129 AFS

DOT HS-805 856

A COMPARISON OF THE AUTOMATIC SHOULDER BELT/KNEE BOLSTER RESTRAINT SYSTEM WITH THE LAP AND SHOULDER BELT SYSTEM IN VW RABBITS

George Y. H. Chi
Donald W. Reinfurt

Highway Safety Research Center
University of North Carolina
Chapel Hill, NC 27514

Contract No. DTNH22-80-C-07189
Contract Amt. $55,826

MARCH 1981
FINAL REPORT

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

Technical Report Documentation Page

1. Report No	2. Government Accession No	3. Recipient's Catalog No
DOT-HS-805-856		

4. Title and Subtitle	5. Report Date
A Comparison of the Automatic Shoulder Belt/Knee Bolster Restraint System with the Lap and Shoulder Belt System in VW Rabbits	March 31, 1981
	6. Performing Organization Code
7. Author(s) George Y. H. Chi and Donald W. Reinfurt	8. Performing Organization Report No
9. Performing Organization Name and Address Highway Safety Research Center University of North Carolina Chapel Hill, NC 27514	10. Work Unit No (TRAIS) 11. Contract or Grant No DTNH22-80-C-07189
12. Sponsoring Agency Name and Address Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, DC 20590	13. Type of Report and Period Covered Final Report April 18, 1980-March 31, 1981 14. Sponsoring Agency Code

15. Supplementary Notes

None

16. Abstract

The primary objective of this research is to assess the (A+K)-injury reducing effectiveness of the VW Rabbit automatic shoulder belt/knee bolster system using statewide police-reported accident data. The analyses are aimed at answering questions about (1) injury rate differences (manual vs automatic); (2) restraint usage rate differences; (3) performance differences between systems (when used); (4) the proportion of injury rate reduction attributable to restraint usage rate differences; and (5) adequacy of state accident data to carry out such investigations.

The study data consists of 10,336 accidents involving VW Rabbits during the period 1975-1979 in New York, North Carolina, Maryland, Colorado, Alabama and South Carolina. The analyses generally involved the following: (1) investigation of potential biases arising from missing belt usage cases; (2) identifying confounding variables by variable screening and then smoothing the data using weighted least squares procedures for categorical data; and (3) examination of the components of the overall (A+K)-injury rate reduction, namely components due to usage rate differences, belt system differences and sample variation.

For the primary analyses (NY, NC, MD, CO), the range of usage rates was 16.6% to 41.6% for manual belts versus 43.1% to 73.7% for automatic belts. Occupants in automatic belt Rabbits experienced 20 to 30 percent fewer (A+K)-injuries than their counterparts in Rabbits with conventional 3-point belt systems. The overriding factor for this reduction was the increase (at least two-fold) in the belt usage rates in the automatic belt Rabbits. When used, the two belt systems are equally effective in preventing serious injuries.

(continue on next page)

17. Key Words	18. Distribution Statement
Automatic (passive) seat belt Manual (active) seat belt Seat belt usage rate Serious injury rate	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	125	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Abstract (cont.)

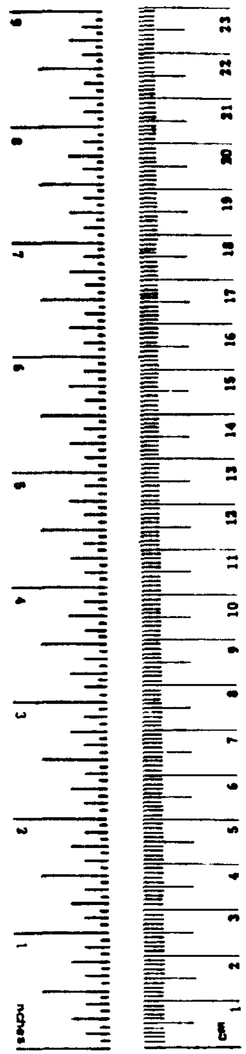
Although there is some variability in the results across states due to differences in reporting thresholds, variable differences, missing data rates, police reporting errors, etc., the reasonable consistency of the results between states suggests a reasonable adequacy of state accident data in addressing a question such as posed herein. In point of fact, alternative data is not yet available.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

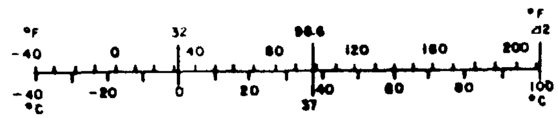
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10 000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



TECHNICAL SUMMARY

Federal Motor Vehicle Safety Standard 208: Occupant Crash Protection (effective January 1, 1968) required the installation of lap and shoulder seat belt assemblies at the front outboard seating positions in all cars (except convertibles) and lap belt assemblies at all other designated seating positions. However, despite the proven effectiveness of safety belts in reducing the level of injury of persons involved in automobile crashes, the overwhelming majority of Americans have continued to choose not to buckle up. Clearly, the life-saving potential of FMVSS 208 has not been realized.

Considering alternative strategies, NHTSA has initiated rulemaking to require automatic occupant crash protection to be built into new cars, since passage of mandatory belt usage laws in the United States has not appeared likely. Among the wide array of passive occupant systems (transparent shields, nets, cushions, arms and barrier, seat belts, integrated seat designs, blankets) developed in the early 1970's, the air bag system as well as the automatic seat belt system have emerged as the most likely automatic restraint systems to satisfy the currently amended FMVSS 208.

Both systems have been extensively tested in laboratory crash situations but field evaluations have been rather limited -- in the air bag case by relatively few air bag cars in operation. The primary objective of this research is to assess the (A+K)-injury reducing effectiveness of the VW Rabbit automatic shoulder belt/knee bolster system using statewide police-reported accident data. The analyses are aimed at answering questions about

(i) Injury rate differences (Manual vs. Automatic)

(ii) Restraint usage rate differences

(iii) Performance differences between systems (when used)

(iv) The proportion of injury rate reduction attributable to restraint usage rate differences

(v) Adequacy of state accident data to carry out such investigations.

The study data consists of VW Rabbit accident data (N=10,336) for the period 1975-1979 from New York, North Carolina, Maryland, Colorado, Alabama and South Carolina. These states were selected since their computerized accident data files contained the Vehicle Identification Number (VIN) which is necessary to identify not only make and model of vehicle (i.e., VW Rabbit) but also available restraint system (i.e., manual vs. automatic). Due to data limitations (quantity and quality), the primary analyses are based on data from New York, North Carolina, Maryland and Colorado.

No attempt has been made to combine data across states due to slightly different definitions of variables (e.g., definition of A-injury), differing reporting thresholds among the states, and occasionally differing distributions of the data among the states (e.g., the "drivable" variable). However, by using the (A+K) injury criterion, there are reasonable sample sizes within each of the states (ranging from 1924 occupants in Colorado to 5046 in New York) with the police determination of A or K injuries appearing to be quite reliable.

The analysis procedures were essentially the same for each state. First, since belt usage is such an important variable and it was missing in from 10 to 15 percent of the cases for the four primary states, an analysis was carried out to see if these missing belt usage cases occur essentially at random; i.e., that they do not introduce any serious biases in the data.

Secondly, in all accident data analyses there are certain variables that interact with the variables of interest -- here, restraint type and serious injury. To the extent allowable by the data, the effect of these confounding variables identified by variable screening procedures was removed by smoothing the data using catégorical data models (i.e., weighted least squares procedures via the GENCAT computer program).

Finally, there is not only interest in the overall (A+K)-injury reduction but also the effect of various components such as usage rate differences and restraint system differences. It can be demonstrated that, after properly controlling for the most relevant confounding factors, the overall injury rate reduction can algebraically be decomposed into three components. The first component is attributable to restraint usage rate differences, the second component attributable to system differences, and the third component to sample variation (or residual). Estimates of these effects were then derived for New York, North Carolina, Maryland and Colorado using the GENCAT program.

Although the unknown belt usage rates are 15.5 percent, 9.5 percent, 13.0 percent and 10.5 percent for New York, North Carolina, Maryland and Colorado, respectively, analysis of these cases indicated no systematic biases that would invalidate the results. Indeed, the unknown belt cases appear to arise essentially randomly in each of the states with respect to the other variables of interest.

In each of the states, among the most important confounding variables to control for were restraint usage and number of vehicles involved (single vs. multi). This consistency increased the confidence in the screening procedure utilized.

Restraint usage rates by system type and state are presented in Table T.1. Although the usage rates differ considerably among the states, the ratio of the rates between belt systems (.506, .386, .564, .637 for NY, NC, MD, CO, respectively) remains reasonably constant with, as expected, a considerable increase in usage with the automatic restraint systems.

Table T.1
Restraint usage rates by system type and state

State	Restraint Usage Rate Manual (s.e.) R_M	 Automatic (s.e.) R_A	 Ratio R_M/R_A
NY	28.96 (1.67)	57.25 (1.84)	0.506
NC	16.63 (1.10)	43.08 (2.66)	0.386
MD	41.60 (1.20)	73.70 (1.83)	0.564
CO	29.37 (2.24)	46.13 (3.97)	0.637

Overall (A+K)-injury rates by system type and state are given in Table T.2 along with (A+K)-injury rate reduction effectiveness estimates. Again, the

Table T.2
Overall (A+K) injury rates and effectiveness estimates by system type and state

State	Overall (A+K) Injury Rate Manual (s.e.) I_M	 Automatic (s.e.) I_A	 Ratio I_M/I_A	Effectiveness (%) $\frac{I_M-I_A}{I_M} \times 100$ (s.e.)
NY	6.33 (0.41)	5.24 (0.72)	1.2	17.27 (12.30)
NC	5.21 (0.65)	3.83 (1.05)	1.4	26.38 (22.06)
MD	2.95 (0.41)	1.84 (0.56)	1.6	37.61 (20.79)
CO	5.07 (0.98)	4.12 (1.17)	1.2	18.78 (27.03)

serious injury rates differ among states due to a combination of the factors -- crash severity differences, reporting threshold differences, reporting errors, and definitional differences in A-injuries. Nonetheless, the ratio (I_M/I_A) is quite constant across states (1.2, 1.4, 1.6, 1.2, respectively).

Table T.3 provides the estimates (s.e.) of the various components of the serious injury rate reduction; i.e., the components due to restraint usage rate differences, system differences, and sample variation (or residual). To the extent that the serious injury rates are significantly reduced (depending upon the α-level selected) for the automatic Rabbit, the consistent and significant component leading to this reduction is the increased belt usage level for the automatic Rabbit. It would seem that the two systems, when used, are equally effective in reducing serious injuries. It is also apparent from the estimates of sample variation that the most important factors have been accounted for in this analysis.

Not unexpectedly, there are a variety of pros and cons in using state accident data to address questions such as the serious injury reduction of automatic belt systems in VW Rabbits. In spite of many limitations and qualifications, it currently represents the only possible accident data base with which to even begin to answer the question. As is seen in the analysis, there are many reasons for not combining such data across states. Nevertheless, the analysis within multiple states with reasonable data quality does allow for an examination of the consistency of results between states and increases the confidence placed in the results of the analysis. Because of a variety of differences between states (e.g., reporting thresholds, variable definitions, nature of computerized files, missing data rates, police reporting errors), it is to be expected that there will be variability in the estimates derived. The extent and acceptability of this variation for the particular analysis being carried out should then define the answer to the question of the usefulness of state accident data in addressing the question. For the present study, after careful consideration of these factors it is felt that the analyses of New York, North Carolina, Maryland and Colorado data provide most useful and otherwise unavailable input into answering the questions posed.

In summary, from this real-world accident data from New York, North Carolina, Maryland and Colorado, occupants in automatic belt Rabbits experienced some 20 to 30 percent fewer (A+K) injuries than their counterparts in Rabbits with conventional 3-point belt systems. The overriding factor for this reduction was an increase (at least two-fold) in the belt usage rates in the automatic belt Rabbits.

Table T.3

Estimates of the components of the overall serious injury rate reduction

	Estimate (s.e.)	95% Confidence Interval	Percentage Relative to Overall (A+K)-Injury for Manual Rabbit (s.e.)
Overall (A+K)-Injury Rate Reduction (I_M-I_A)			
NY	1.09% (0.81%)	(-0.50%, 2.68%)	17.27% (12.30%)
NC	1.38% (1.23%)	(-1.17%, 3.63%)	26.38% (22.06%)
MD	1.11% (0.69%)	(-0.24%, 2.46%)	37.61% (20.79%)
CO	0.95% (1.47%)	(-0.97%, 2.87%)	18.78% (27.03%)
Component Attributed to Restraint Usage Rate Differences			
NY	1.22% (0.23%)*	(0.77%, 1.67%)	19.27% (3.34%)*
NC	0.85% (0.45%)**	(-0.02%, 1.72%)	16.33% (8.40%)**
MD	0.46% (0.26%)**	(-0.05%, 0.97%)	15.55% (8.66%)**
CO	0.70% (0.36%)**	(-0.01%, 1.41%)	13.87% (7.81%)**
Component Attributed to System Differences			
NY	-0.22% (0.56%)	(-1.32%, 0.88%)	-3.48% (8.85%)
NC	-0.35% (0.87%)	(-2.07%, 1.36%)	-6.81% (17.12%)
MD	0.74% (0.55%)	(-0.34%, 1.82%)	25.21% (17.61%)
CO	-0.57% (0.84%)	(-2.20%, 1 06%)	-11.31% (16.79%)
Component Attributed to Sample Variation (Residual)			
NY	0.09% (0.58%)	(-1.05%, 1.23%)	1.48% (7.92%)
NC	0.88% (0.90%)	(-0.89%, 2.64%)	16.87% (16.62%)
MD	-0.09% (0.44%)	(-0.96%, 0.77%)	-3.15% (14.88%)
CO	0.82% (1.30%)	(-1.73%, 2.65%)	16.22% (23.63%)

*Significant at $\alpha = 0.05$
**Significant at $\alpha = 0.10$

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ACKNOWLEDGMENTS

The authors wish to acknowledge the many individuals whose contributions made this study possible. Of special mention are the personnel at the various state motor vehicle agencies: Major Harold Hammond and Mr. David Murrell (ALABAMA); Mr. William Smyth and Mr. Lowell Roberts (COLORADO); Sergeant Thomas Bailey (MARYLAND); Mr. Charles Bostick (NEW YORK); Mr. Laeron Roberts and Mr. Joseph Register (NORTH CAROLINA); and Mr. R. Preston Smith (SOUTH CAROLINA).

Particular appreciation is expressed to Ms. Jane Stutts of HSRC who not only wrote most of Chapter 1 but was a valuable resource throughout the project. Dr. J. Richard Stewart of HSRC and Dr. Gary Koch of the UNC Department of Biostatistics provided statistical sounding boards during the developmental stages of the analysis procedure.

Special thanks are due Ms. Anita Leung, Mr. Chesley Williams, and Mr. Paul Guthery of the HSRC computing staff for their assistance in working with the various state accident data files. Several individuals contributed greatly during the various phases of the report preparation. These include typists Ms. Peggy James, Ms. Teresa Parks, and Ms. Donna Suttles and graphic artist, Ms. Cranine Brinkhous.

Last, and certainly not least, the authors are greatly indebted to Mr. John Van Dyke, the Contract Technical Manager, and Dr. James Hedlund, both of NHTSA, for their guidance and input during all phases of this project.

CHAPTER 1. INTRODUCTION

Background

In 1966 Congress enacted the National Traffic and Motor Vehicle Safety Act, giving the Secretary of Transportation the authority to issue federal motor vehicle safety standards (FMVSS's) directed at reducing motor vehicle accidents and the deaths and injuries resulting from them. The legislation was part of an "aggressive highway safety program" that also included the creation of the current National Highway Traffic Safety Administration (NHTSA). NHTSA was delegated the responsibility of designing, implementing and evaluating the safety standards. In the past 15 years over 50 safety standards have been promulgated following federal rulemaking procedures.

One of the earliest standards issued was FMVSS 208 - Occupant Crash Protection. This standard has required the installation of lap and shoulder seat belt assemblies at the front outboard seating positions in all cars (except convertibles) and lap belt assemblies at all other designated seating positions. The standard became effective January 1, 1968.

FMVSS 208 has differed from most other standards in that its effectiveness has depended on the willingness of the occupant to utilize the available safety equipment. Despite the proven effectiveness of safety belts in reducing the level of injury of persons involved in automobile crashes, the overwhelming majority of Americans have continued to choose <u>not</u> to buckle up. The most recent estimates by NHTSA have placed seat belt usage for drivers in the general population at 11 percent, and the figure for other occupants in the car is even lower. Clearly, the life-saving benefits of FMVSS 208 have not been realized.

One "solution" to this problem which was applied to 1974 model vehicles was to require an ignition interlock system, with the car wired so that it would not start unless the seat belt had been buckled. This drew such strong adverse reaction from the public that the requirement was quickly rescinded by Congress. Another alternative which has been adopted in at least 23 foreign countries with considerably more success is mandatory belt usage laws. In countries that have passed such laws and have also instigated some visible program of enforcement, results have been most encouraging. In Australia, for example, belt usage has been observed at 80-90 percent (McDermott and Hough, 1979). In addition, public reaction to mandatory belt usage laws in these countries has generally been favorable.

Given the current political environment in the United States it is doubtful that, with the exception of child restraint legislation, widespread mandatory belt usage laws will be enacted. Realizing this the NHTSA as early as 1969 initiated rulemaking to require automatic occupant crash protection to be built into new cars. Such automatic or passive restraints would not require any action on the part of the motor vehicle occupant to be effective.

In response to this policy the early 1970's witnessed the development of a wide array of passive occupant restraint systems in the form of transparent shields, nets, cushions, arms and barriers, seat belts, integrated seat designs, and blankets. Many of these are described in a report to NHTSA by Beta Industries, Inc. (Phillips, 1973). In the study, patent, literature and manufacturer surveys were conducted to gather information on passive restraint systems "other than inflatables." Approximately 40 different systems are described, including

- a net device stored in the roof of the car and extracted into position around the passenger compartment by spring loaded actuators;
- an inverted U-shaped safety shield made of a flexible transparent material detachably secured to the seat belt and anchored at the ceiling and at the floor attachment points to the seat belts;
- a cushioned panel deployed from the dashboard that swings into position in front of the torso;
- a "floating arm" that consists of a cushioned pad resting in the chest area, held there by light pressure and pivoted from the floor;
- inflatable flexible arms that are able to grasp the occupant over the shoulders and around the waist;
- the Firestone Safety Blanket, automatically pulled up against the chest in the event of a crash;
- the Kinematic Safety Seat system, which upon impact automatically tilts the seat bench and back so that the spine is in a reclined position; and
- a variety of passive belt systems patented in the U.S., Sweden, West Germany, Japan and Italy, including several inflatable belt systems.

From this early barrage of passive restraint innovations, two primary systems have emerged as practical and effective alternatives to manual or active seat belts. These are the General Motor's air bag and Volkswagen's automatic belt system. Both have been extensively tested in laboratory crash situations, and have also been sold to the public in sufficient numbers to permit limited field evaluation. The GM air bag was first made available on 1000 1973 model Chevrolets and then also on certain luxury model cars during 1974-76, with the result that today there are an estimated 10,000 GM air bag vehicles on the road. Air bags have also been available on some Volvos and some 831 1971 model Ford Mercurys. Volkswagen Rabbits equipped with automatic belt systems were first introduced in 1975, and current U.S. sales total approximately 300,000. A similar sort of automatic belt system has also been available on certain GM Chevettes since the 1978 model.

As currently amended, FMVSS 208 requires that automatic or passive restraints be available on all luxury, medium and standard-sized cars (wheelbases greater than 114 inches) manufactured after September 1, 1981; all intermediate and compact cars (wheelbases greater than 100 inches) manufactured after September 1, 1982; and all subcompacts after September 1, 1983. Since the standard is, by law, performance oriented rather than design oriented, car manufacturers have the option of choosing the particular system they will install to meet the federal requirements. Because of design problems and production costs, most of the auto manufacturers appear to be opting for a passive belt system.

Objective of This Study

The Volkswagen automatic restraint system consists of a torso belt with dual sensitivity automatic locking retractor, a knee bolster, and the seat and seat belt anchorage on the seat frame (see Figure 1.1). The torso belt is attached at its upper end to a release latch mounted on the door and is designed so that as the door is opened the belt swings out of the way to allow seating. The knee bolster is designed to absorb energy transmitted through the knees and is intended to replace the conventional lap belt. An electric switch installed in the belt buckle prevents the engine from starting if the driver is unbuckled.

To date most of the testing of the VW Rabbit automatic restraint system has been carried out in the laboratory under simulated crash conditions, although some limited field evaluations have been conducted by NHTSA and Volkswagen of America. The primary objective of this research is to assess the injury

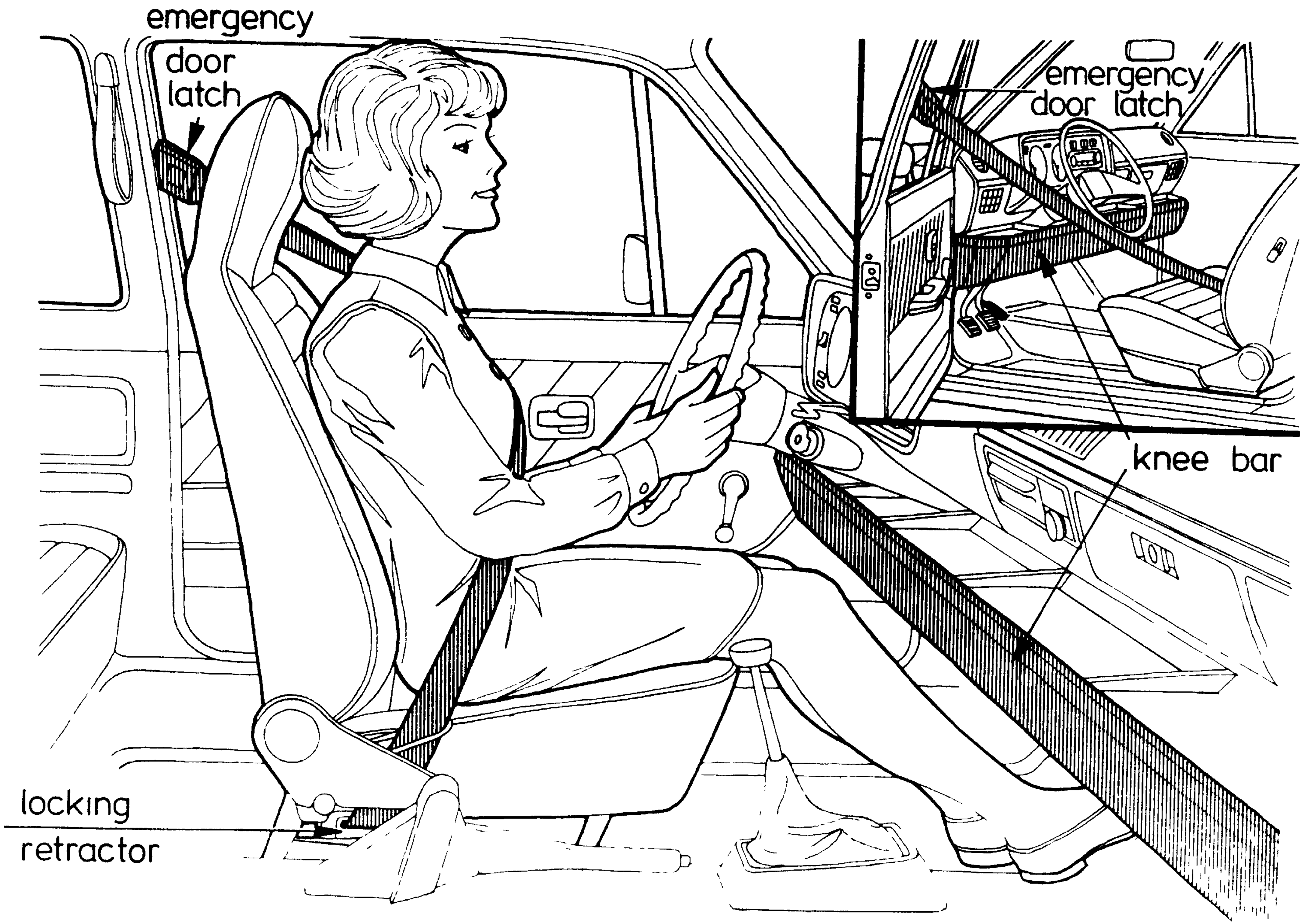

Figure 1.1. The Volkswagen Rabbit automatic restraint system.
Source: Rosenau and Welkey (1980).

reducing effectiveness of the VW Rabbit automatic shoulder belt/knee bolster system using police reported accident data from six states - New York, North Carolina, Maryland, Colorado, Alabama and South Carolina. Specifically, accident data from these states are analyzed to compare the injury experiences of front seat, outboard occupants of VW Rabbits equipped with automatic restraint systems with those equipped with manual (active) lap and shoulder belt systems. The analyses are aimed at answering the following questions:

(i) Do occupants of VW Rabbits with automatic restraint systems experience significantly lower injury rates than the occupants of VW Rabbits with manual restraint systems under similar crash conditions?

(ii) Do occupants of VW Rabbits with automatic restraint systems have significantly higher restraint usage rates than occupants of VW Rabbits with manual restraint systems?

(iii) When both types of restraint systems are in effect, do the automatic restraint systems perform better or worse or about the same as the manual restraint systems?

(iv) If the answers to questions (i) and (ii) are both in the affirmative, then how much of the reduction in the injury rate for occupants of VW Rabbits with automatic restraint systems is attributable to the corresponding increase in their restraint usage rate?

(v) To what extent is state accident data adequate for addressing questions such as these?

Review of the Literature

Restraint Usage Studies

As noted earlier, the primary reason for amending FMVSS 208 to require the installation of automatic (or passive) restraints in new automobiles is the low use level associated with the manual systems. An automatic restraint system by definition requires no action on the part of the vehicle operator to be effective. However, especially in the case of automatic belts, there does exist the possibility for defeating the system, or altering it so that the vehicle can be operated without the safety belt in use. Real world usage rates must therefore be considered in an evaluation of the potential effectiveness of an automatic belt system.

The most current information in this area comes from a recent survey of 1978 VW Rabbit owners and 1978-79 Chevette owners conducted by the Opinion

Research Corporation (Phillips and Goodman, 1980). Owners were contacted by telephone and asked to respond to a series of questions about belt usage, comfort, convenience and reliability, and about approaches used by the salesman at the time of purchase. A total of 2,431 interviews were completed, distributed as follows:

VW Rabbit with automatic restraint system	1,010
VW Rabbit with manual restraint system	203
GM Chevette with automatic restraint system	1,002
GM Chevette with manual restraint system	216
Total	2,431

Eighty-nine percent of the owners of the VW Rabbits with automatic restraint systems reported that they wore their belt "always" or "almost always," compared with 46 percent of the owners of manual belt equipped Rabbits. For the Chevettes the corresponding figures were 72 percent for the automatic Chevettes and 34 percent for the manual Chevettes. These reported usage rates are noted to be at least 10 percent higher than actual observed usage rates based on data from Opinion Research Corporation (ORC) belt usage surveys conducted in 19 cities across the U.S. (see Table 1.1).

Table 1.1

Reported and Observed Belt Usage
by Owners of VW Rabbits and GM Chevettes

	Reported Usage	Observed Usage
Automatic Rabbit Owners	89%	81%
Manual Rabbit Owners	46%	36%
Automatic Chevette Owners	72%	no data
Manual Chevette Owners	34%	11%

Source: Phillips and Goodman (1980)

Generally owners of the Chevettes viewed their automatic restraint systems less favorably and were more critical on points related to the comfort and convenience of the system. However, they were apparently no more likely to have defeated their system. The starter interlock was reported still operative in 89 percent of the Chevettes after an average ownership of nine months, and 88 percent of the VW Rabbits after an average ownership of 12 months.

Given a longer period of ownership, one could expect this defeat rate to increase due to, among other things, increased transferal of ownership. NHTSA estimates that the disconnect rate of VW Rabbits will range from 20-40 percent (NHTSA, 1980). A 30 percent defeat rate was observed for 1975-78 automatic belt-equipped Rabbits (NHTSA, 1978).

Compared with observed belt usage in the general population of automobile drivers, usage in even the manual belt-equipped VW Rabbits is high. As referred to earlier, NHTSA's most recent figures for belt usage in the general population are 11 percent for drivers (the same as observed for drivers of manual Chevettes in the 19 city ORC survey) and seven percent for other occupants of the vehicle. Usage is consistently higher in the smaller foreign make cars. In a 1977-78 ORC survey where the overall observed usage was 16 percent, U.S. car usage was 14 percent and foreign car usage was 23 percent. Also, it is known that usage in the general population, the "population at risk," is higher than in the population of accident-involved drivers. For example, only eight percent of the drivers in accidents sampled for the National Crash Severity Study were wearing their belts (NHTSA, 1979).

On the basis of these data it is clear that automatic belt systems go a long way toward resolving the problem of nonuse of available safety restraints. The question which remains to be answered is how effective these passive belt systems are when compared to other restraint systems in general and manual lap and shoulder belt systems in particular. Research in this area is briefly reviewed in the following section.

Restraint Efectiveness Studies

Four major approaches have been taken to estimating the effectiveness of passive restraint systems. These are summarized and critiqued in a report to the General Accounting Office by Griffin (1979). Briefly, these four approaches are:

(i) Laboratory assessments (artificial studies)
(ii) Subjective assessments (engineering judgments)
(iii) Systems models (flow charts, statistical equations)
(iv) Real-world accident experience (naturalistic studies)

Griffin argues that while all four types of evaluation can be useful tools to the highway safety researcher, only the last constitutes a reliable and valid means of determining a countermeasure's worth.

As noted earlier most of the evaluations that have been carried out on the VW Rabbit automatic belt/knee bolster system have been in a laboratory setting. The system was extensively tested at the University of Heidelberg and in VW's own labs before being marketed to the public. Seiffert, Oehm and Paitula (1974) concluded on the basis of their simulated lab tests of frontal, lateral and rollover crash types that the VW automatic restraint "performs as well or better than the three-point belt." And in evaluating the results of a limited number of frontal crash tests using cadavers, Schimkat, Weissner and Schmidt (1974) arrived at a similar conclusion, stating that the two types of restraint systems offer equal occupant protection.

Further lab testing of the VW Rabbit automatic belt system was carried out as part of NHTSA's compliance testing for FMVSS 208. In the initial round of testing involving eight frontal impacts, there were some problems with the restraint on the driver side of the vehicle. Later testing by NHTSA in 1976-77 showed the VW automatic belt/knee bolster system to be in full compliance with federal requirements for frontal crash protection.

The "subjective assessment" approach was used by Huelke, Sherman, Murphy, Kaplan and Flora (1979) to evaluate the potential effectiveness of a variety of restraint systems. NASS-type data collected at the scene of 80 fatal crashes occurring in Washtenaw County, Michigan, during 1973-77 were examined by the authors. Three of the authors, Sherman, Murphy and Kaplan, independently estimated the injury-reducing effect that lap belts, lap and shoulder belts, air bags with and without lap belts, and passive belts would have had had they been used by the accident victim. The following average effectiveness figures were given for reducing the likelihood of death and the level of injury from serious, or fatal (AIS $\geq$3) to moderate, minor or uninjured (AIS $\leq$2):

Restraint System	% Fewer Fatalities	% Fewer Serious Injuries
Lap belt	12%	39%
Lap and shoulder belt	32%	64%
Air bag only	25%	58%
Air bag with lap belt	34%	68%
Automatic belt	28%	58%

Compared with NHTSA's effectiveness estimates, which have generally been based on mass accident data analysis, the estimates cited here for fatality reduction are considerably lower, while those for serious injury reduction are higher. For example, analysis of the RSEP (Restraint Systems Evaluation Program) data indicated that in accidents in which at least one vehicle had to be towed from the scene, lap/shoulder belts were 57 percent effective in reducing serious (AIS $\geq$2) injuries (Reinfurt, Silva and Seila, 1976). One explanation offered by Huelke et al. is the relatively rural, high speed setting for most of the accidents they examined, resulting in a sample of accidents that was less "survivable" than what would be expected for mass accident data. Nevertheless, it is interesting to note that the automatic belt system was judged to perform slightly better than air bags alone but not quite as well as the conventional lap and shoulder belt systems. This might be expected since air bags are designed to offer protection in frontal collisions only.

Most of the studies of automatic belt effectiveness that have been conducted using real world accident data have been limited to fatal accident cases reported through the national Fatal Accident Reporting System (FARS). The FARS data has been actively monitored by NHTSA for the purpose of evaluating the field safety performance of VW Rabbits since the fall of 1977.

In an analysis of FARS data collected through September 1978, NHTSA reports that the fatality rate per 1000 car years is 0.137 for automatic (or passive) belt-equipped VW Rabbits and 0.281 for manual (or active) belt-equipped Rabbits of the same model years. From this data, the fatality rate for automatic belt Rabbits is seen to be about half the rate for the manual belt Rabbits. Although increased usage is seen as the major factor affecting this reduction in fatalities, the effect of usage *per se* was not differentiated in the analysis.

In addition to NHTSA's analysis of the FARS data, Volkswagen has initiated some field evaluations of its own. For the past several years Volkswagen has received the cooperation of its U.S. dealers in notifying it of all crashes of automatic belt-equipped VW Rabbits involving at least $2,500 damage. These are then extensively investigated by Volkswagen personnel. Rosenau and Welkey (1980) report on the 147 crashes investigated to date, 61 percent of these being frontal collisions ($\pm$ 45°), 20 percent lateral collisions, 11 percent rear end collisions and 8 percent rollovers. There were no reported fatalities and the highest AIS recorded in the sample was AIS 4. The reported belt usage rate was quite high at 95 percent. From their examination of this real-world data the authors conclude that the VW Rabbit automatic belt/knee bolster restraint system performs according to original expectations, and that there is no need for mandating "any specific type of automatic occupant protection, such as air cushions."

In their 1980 study, Rosenau and Welkey also review laboratory testing of the VW automatic and manual restraint systems. In full frontal crash tests, higher HIC (Head Injury Criteria) values, measuring head forces upon impact, were recorded for the manually restrained occupants, while the passively restrained occupants experienced greater femur forces. Chest accelerations recorded under the two conditions were comparable. For the 30° frontal barrier crash tests, HIC values for the conventionally and passively restrained occupants were similar, but the passively restrained occupants experienced slightly higher chest accelerations and femur forces. They conclude once again that on the basis of these crash tests, the two systems, when used, are virtually equivalent in terms of occupant protection.

There are obvious limitations in both the NHTSA and Volkswagen field evaluations of the VW Rabbit automatic restraint system. The FARS data used in the NHTSA analysis is restricted to fatal accidents, and the number of crashes investigated by Volkswagen is still relatively small and there is no comparison evaluation of crashes involving manually restrained occupants. The current research attempts to overcome these limitations by utilizing mass accident data from six states for the five-year period 1975-1979. As noted earlier, the six states are New York, North Carolina, Maryland, Colorado, Alabama and South Carolina. These six states were selected because reporting officers in these states record the Vehicle Identification Number (VIN) of vehicles involved in crashes and this information is in turn stored on the computerized accident data files. VIN information is needed to identify vehicle make and model and, in the case of VW Rabbits, the type of available restraint system (automatic or manual).

Chapter 2 gives a detailed description of the data bases utilized in the current analysis. Study methodology is outlined in Chapter 3 and the results presented in Chapter 4. A final chapter discusses the significance of the study findings and the appropriateness of using police-reported mass accident data to carry out such evaluations.

CHAPTER 2. THE DATA

Introduction

The data used in this study consists of police-reported accident data from New York State, North Carolina, Maryland, Colorado, Alabama, and South Carolina for the calendar years 1975-1979. For New York State, the data consists primarily of injury accidents since the police do not report on Property Damage Only (PDO) accidents. Although there is information on PDO crashes reported by the motorist, the data was not utilized since many of the variables of interest (e.g., restraint usage, seating position) were either not required on the motorist report form or a substantial proportion were left blank.

For the remaining states, the thresholds for police reporting are quite similar (i.e., injury and/or property damage of several hundred dollars) and thus the police reports represent the full range of accident severity. (See Appendix A for copies of the accident report forms for each of the states.)

A primary objective of this study is to determine whether occupants of VW Rabbits with automatic restraint systems experience significantly lower serious (A or K) injury rates than do the occupants of VW Rabbits with manual restraint systems under similar crash conditions. Secondary objectives are to determine whether there are significant differences in restraint system usage rates (automatic vs. manual) and whether automatic restraint systems perform better or worse or about the same as the manual restraint systems. Obviously to address these questions, it is necessary to separate out the Rabbit accidents in each of the state files and then to ascertain which Rabbits had automatic restraints and which ones had manual systems.

Thus, with the help of the documentation provided by each of the states along with some consultation, each of the accident files was processed and an extract made of those accidents involving VW Rabbits. It should be noted that, although the automatic belts were available on the more "luxurious" Rabbits, the fact that both systems were available in the same make/model vehicle makes for a nearly ideal study design (i.e., vehicle and driver differences between the experimental group and the control group should be at a minimum).

To identify Rabbit-involved accidents, it was necessary to have accident files with computerized Vehicle Identification Number (VIN) information and hence the selection of New York State, North Carolina, Maryland, Colorado, Alabama, and South Carolina. Using the R. L. Polk VINA package (a VIN decoding program), the previously mentioned extract was created (see Table 2.1).

Table 2.1
VW Rabbit accidents by state [percent of total]

State	Number of Rabbit Accidents [%]
New York	3898 [32.5]
North Carolina	1841 [15.4]
Maryland	2474 [20.7]
Colorado	2061 [17.2]
Alabama	1175 [9.8]
South Carolina	527 [4.4]
Total	11976

The next step involved identifying the restraint type for each of the Rabbits. This information is contained in the production number which is a series of digits at the end of the VIN sequence. Thus, to obtain the restraint type, the Rabbit VIN's were passed against a VW-supplied file which provided a listing of restraint type by production number. As anticipated cases were deleted due to invalid production numbers either provided by the investigating officer or entered incorrectly from the report form onto the computer file. The resulting study file is shown in Table 2.2. As can be seen, the automatic restraint system constitutes between 20 and 26 percent of the cases in each state and is reasonably constant from state to state as should be expected.

Characteristics of the Study File

Accident-Oriented Comparisons. For each state, an accident (or vehicle = Rabbit) oriented file was created in order to examine differences between restraint types with respect to model year, accident year, number of vehicles involved (single vs. multi), impact area (of Rabbit), extent of damage, drivability, and weight of the other vehicle (in multivehicle crashes). To the extent that the data is available and comparable across states, the resulting distributions are shown in Tables 2.3 - 2.6.

Table 2.2

Frequency (percentage) of Rabbit restraint system type by state

	Belt Type (%)		
	Manual	Automatic	Total
New York	2821 (79.6)	722 (20.4)	3543 [34.3]
North Carolina	1180 (77.3)	347 (22.7)	1527 [14.8]
Maryland	1603 (75.3)	525 (24.7)	2128 [20.6]
Colorado	1434 (74.5)	491 (25.5)	1925 [18.6]
Alabama	768 (79.1)	203 (20.9)	971 [9.4]
South Carolina	190 (78.5)	52 (21.5)	242 [2.3]
Total	7996 (77.4)	2340 (22.6)	10,336

The relatively low percentage of 1979 model Rabbits in the accident file (see Table 2.3) should be expected since, for the most part, they could only be involved in accidents during calendar year 1979 which represents at most only one-fifth of the accident period -- less than this for states with less than a full year of data for 1979. It is of interest that 1979 model automatic Rabbits are consistently underrepresented as compared to manual Rabbits especially when compared to the reasonably similar distribution for each of the other model year vehicles. Note should be made, however, of the relatively small within-state accident sample sizes for the 1979 model year Rabbit.

The accident year distribution (see Table 2.4) appears reasonable (i.e., increasing numbers of Rabbits of both types as more and more model years come into existence). The only exception is calendar year 1979 which can be explained by less than a full year of accident data for some of the states. South Carolina deviates the most from the overall rates. The extent to which this is a function of small sample size vs. the quality of the VIN data (i.e.,

Table 2.3

Rabbit model year distribution by Rabbit belt type by state.

State	Belt Type	Model Year					Total
		1975	1976	1977	1978	1979	
NY	Manual	806	860	608	431	116	2821
	(%)	(28.6)	(30.5)	(21.6)	(15.3)	(4.1)	[79.6]
	Automatic	206	205	167	139	5	722
	(%)	(28.5)	(28.4)	(23.1)	(19.3)	(0.7)	[20.4]
NC	Manual	363	242	324	191	60	1180
	(%)	(30.8)	(20.5)	(27.5)	(16.2)	(5.1)	[77.3]
	Automatic	97	76	83	88	3	347
	(%)	(28.0)	(21.9)	(23.9)	(25.4)	(0.9)	[22.7]
MD	Manual	396	349	551	247	60	1603
	(%)	(24.7)	(21.8)	(34.4)	(15.4)	(3.7)	[75.3]
	Automatic	133	155	118	114	5	525
	(%)	(25.3)	(29.5)	(22.5)	(21.7)	(1.0)	[24.7]
CO	Manual	273	389	448	278	46	1434
	(%)	(19.0)	(27.1)	(31.2)	(19.4)	(3.2)	[74.5]
	Automatic	90	145	139	113	4	491
	(%)	(18.3)	(29.5)	(28.3)	(23.0)	(0.8)	[25.5]
AL	Manual	268	116	210	108	30	732
	(%)	(36.6)	(15.9)	(28.7)	(14.8)	(4.1)	[78.8]
	Automatic	66	41	34	55	1	197
	(%)	(33.5)	(20.8)	(17.3)	(27.9)	(0.5)	[21.2]
SC	Manual	60	28	53	40	9	190
	(%)	(31.6)	(14.7)	(27.9)	(21.1)	(4.7)	[78.5]
	Automatic	9	14	12	16	1	52
	(%)	(17.3)	(26.9)	(23.1)	(30.8)	(1.9)	[21.5]
	Total	2767	2620	2747	1820	340	10294
	(%)	(26.9)	(25.5)	(26.7)	(17.7)	(3.3)	

Table 2.4
Accident year distribution by Rabbit belt type by state.

State	Belt Type	Accident Year 1975	1976	1977	1978	1979	Total N	[%]
NY	Manual %	4.9	12.5	21.4	29.1	32.1	2821	[79.6]
	Automatic %	4.2	13.0	22.3	30.3	30.2	722	[20.4]
NC	Manual %	3.2	11.0	20.5	31.2	34.1	1180	[77.3]
	Automatic %	4.0	12.5	17.3	31.8	34.4	347	[22.7]
MD	Manual %	2.5	5.4	29.1	40.6	22.4	1596	[75.3]
	Automatic %	4.4	9.9	23.3	39.6	22.8	523	[24.7]
CO	Manual %	1.3	10.4	21.3	30.8	36.3	1434	[74.5]
	Automatic %	1.4	7.5	22.2	31.4	37.5	491	[25.5]
AL	Manual %	3.0	11.6	23.6	31.8	29.9	732	[78.8]
	Automatic %	2.5	9.1	25.4	28.9	34.0	197	[21.2]
SC	Manual %	5.3	11.1	16.3	30.5	36.8	190	[78.5]
	Automatic %	7.7	1.9	5.8	36.5	48.1	52	[21.5]
Total		349	1068	2326	3336	3206	10285	
%		3.4	10.4	22.6	32.4	31.2		

54 percent of the Rabbit VIN's failed to provide information on the type of belt system) is not able to be determined. Nonetheless, it does suggest caution in utilizing and interpreting South Carolina Rabbit data. As will subsequently be seen, similar caveats will apply to the Alabama accident data.

The distribution of number of vehicles involved (see Table 2.5) by belt type is reasonably consistent across states averaging approximately 12 percent in single vehicle crashes. This is likewise similar to data from North Carolina for 1975-1979 involving all passenger cars.

Crash-involved Rabbits are drivable in roughly two-thirds of the cases (see Table 2.6). Although the between state variation is somewhat greater for this variable perhaps due to slightly differing definitions of "drivable", the within state distributions by belt type are very similar with, again, the exception of South Carolina.

With respect to some of the other vehicle-oriented variables such as impact area and extent of damage, to the extent that the vehicles were defined the same across states comparisons of automatic vs. manual Rabbits revealed similar impact areas (e.g., approximately 35 percent in the front and 25 percent on each side -- slightly higher on the left side) and damage extent (10 percent or so with "severe" damage).

In brief, with respect to accident and/or vehicle variables, the data from the six states is reasonably consistent with expectation and similar by belt type.

Occupant (Driver) - Oriented Comparisons. Clearly to address the objectives of this study, it was necessary to create an occupant-oriented file. From this file information could be derived on, for example, injury by belt type by seating position. It should be noted, however, that for Alabama and South Carolina the file contains driver information only since there is no information available for uninjured occupants. Thus, non-driver occupants from Alabama and South Carolina are excluded from the "occupant" (i.e., driver + right front seat passenger (when present)) tables.

Of special interest are belt type (manual vs. automatic) distributions by restraint usage, injury severity, and age, sex and seating position of occupant. From the state data files for occupants in Rabbits where belt type is known, belt usage information is unavailable for 94 percent of the Alabama data (93 percent manual vs. 96 percent automatic) and 93 percent of the South Carolina cases (92 percent manual vs. 93 percent automatic). As a result, there is very little belt usage information for these two states. However, for the remaining

Table 2.5

Distribution of number of vehicles involved by Rabbit belt type by state.

State	Belt Type	Number of Vehicles Involved		Total	
		Single	Multi	N	[%]
NY	Manual %	15.9	84.1	2821	[79.6]
	Automatic %	15.2	84.8	722	[20.4]
NC	Manual %	13.0	87.0	1180	[77.3]
	Automatic %	13.0	87.0	347	[22.7]
MD	Manual %	8.8	91.2	1603	[75.3]
	Automatic %	9.0	91.0	525	[24.7]
CO	Manual %	10.3	89.7	1434	[74.5]
	Automatic %	8.6	91.6	491	[25.5]
AL	Manual %	9.7	90.3	732	[78.8]
	Automatic %	11.7	88.3	197	[21.2]
SC	Manual %	15.3	84.7	190	[78.5]
	Automatic %	13.5	86.5	52	[21.5]
Total		1263	9031	10294	
%		12.3	87.7		

Table 2.6

Vehicle (Rabbit) drivability by belt type by state.

State	Belt Type	Drivability Yes	Drivability No	Total N	Total [%]
NY	Manual %	72.0	28.0	2821	[79.6]
	Automatic %	71.6	28.4	722	[20.4]
NC	Manual %	55 9	44.1	1066	[77.7]
	Automatic %	59.2	40.8	306	[22.3]
MD	Manual %	71.2	28.8	1578	[75.1]
	Automatic %	72.5	27.5	523	[24.9]
CO	Manual %	66.8	33.2	1309	[74.3]
	Automatic %	67.7	32.3	452	[25.7]
AL	Manual %	67.4	32.6	720	[78.6]
	Automatic %	67.3	32.7	196	[21.4]
SC	Manual %	51.6	48.4	190	[78.5]
	Automatic %	65.4	34.6	52	[21.5]
Total		6756	3179	9935	
%		68.0	32.0		

states, the rates of unknown belt usage range from under 10 percent for North Carolina to around 15 percent for New York State. It will be seen in Chapter 4 that there are no serious biases created by the missing belt usage information which would undermine any subsequent analyses.

From Table 2.7 it would appear that usage of the automatic belt in crashes is at least double that of the manual belt. Although the percentages differ considerably from state-to-state, the ratio of the rates is reasonably constant (1.97 for New York State; 2.61 for North Carolina; 1.78 for Maryland; and 1.84 for Colorado). Since the VW Rabbit is a foreign, subcompact, one would expect higher-than-average usage rates for the conventional (or manual) belts. On the other hand, based on population-at-risk studies and the fact that there is an ignition interlock accompanying the automatic belts, generally higher usage rates (exceeding 70 percent) would be anticipated. Misclassification errors by the investigating officer (generally indicating that the belt was not worn when indeed it had been for the automatic Rabbits) would account for these lower than expected usage rates for automatic belts. However, errors in the same direction would be expected for the manual belts which does not appear to be the case.

In addition, it would be anticipated that the belt usage rate for type would be fairly similar from state to state. Whether the differences are systematic reporting differences between states is not known. There is no independent source against which to compare the investigator's designation. Until such is available, it is probably safe to assume only that automatic belts were used at least twice as often as conventional belts in the set of accidents under study. The data from New York, North Carolina, Maryland and Colorado suggests a range in usage rates for manual belts of 25-30 percent and one of 55-60 percent for automatic belts.

Table 2.8 shows serious (A+K) injury rates by belt type and by state. Again, the ratio of serious injury rates (manual vs. automatic) are reasonably stable across states (1.28 for New York; 1.38 for North Carolina; 1.71 for Maryland; and 1.18 for Colorado) while the serious injury rates within belt type vary considerably across states (e.g., for manual belts from 2.9 percent for Maryland to 8.5 percent for Colorado). This variation could be a function of: (1) differences in crash severity among states; (2) differences in reporting thresholds; (3) errors in reporting level of injury level; and (4) differences in the definition of serious (A+K) injury.

Table 2.7
Occupant belt use by Rabbit belt type by state

State	Belt Type	Belt Use Yes	Belt Use No	Total N	Total [%]
NY	Manual %	29.0	71.0	3401	[79.8]
	Automatic %	57.2	42.8	860	[20.2]
NC	Manual %	16.3	83.7	1426	[77.1]
	Automatic %	42.6	57.4	425	[22.9]
MD	Manual %	41.6	58.4	1696	[74.6]
	Automatic %	73.9	26.1	578	[25.4]
CO	Manual %	25.4	74.6	1394	[75.1]
	Automatic %	46.8	53.2	462	[24.9]
AL*	Manual %	2.1	97.9	48	[85.7]
	Automatic %	37.5	62.5	8	[14.3]
SC*	Manual %	7.1	92.9	14	[82.4]
	Automatic %	33.3	66.4	3	[17.6]
	Total	3600	6715	10315	
	%	34.9	65.1		

*Based on drivers only

Table 2.8

Occupant (A+K)-injury distribution by Rabbit belt type by state.

State	Belt Type	Injury Level A+K	Injury Level B+C+0	Total N	Total [%]
NY	Manual %	6.0	94.0	4015	[79.6]
	Automatic %	4.7	95.3	1031	[20.4]
NC	Manual %	4.7	95.3	1580	[77.2]
	Automatic %	3.4	96.6	467	[22.8]
MD	Manual %	2.9	97.1	1949	[75.3]
	Automatic %	1.7	98.3	640	[24.7]
CO	Manual %	8.5	91.5	1449	[75.3]
	Automatic %	7.2	92.8	475	[24.7]
AL*	Manual %	7.2	92.8	732	[78.8]
	Automatic %	2.0	98.0	197	[21.2]
SC*	Manual %	4.7	95.3	190	[78.5]
	Automatic %	1.9	98.1	52	[21.5]
Total		672	12105	12777	
%		5.3	94.7		

*Based on drivers only.

Figure 2.1

Translation of New York State Injury Coding Scheme to K-A-B-C-O

Victim's Injury Status	Type of Complaint	Location of Injury	Translation to KABCO
I. Apparent death (1)	Any entry	Any entry	K
II. Unconscious (2) Semi-conscious (3) Incoherent (6)	Any entry	Any entry	A
III Shock (7) Normal (8)	Amputation, Concussion, Internal, Severe bleeding, Severe burn, Fracture-dislocation	Any entry	A
IV. Shock (7) Normal (8)	Minor bleeding, Minor burn, Complaint of pain	Eye	A
V. Shock (7) Normal (8)	Minor bleeding, Minor burn	All but eye	B
VI. Shock (7)	Contusions-bruise Abrasion	Any entry	B
VII. Shock (7) Normal (8)	Complaint of pain	All but eye	C
VIII. Shock (7) Normal (8)	None visible	Any entry	0
IX. Not applicable (0)	Vehicle parked	D	(No occupant)
X .		W	(No vehicle)
XI. Not applicable (0)	For driver, if driver position=1, For right front occupant, if occupant position=3.		0
XII. Not applicable (0)	For driver, property damage='Yes'+ total injured in accidnet='None'. For right front occupant, property damage='Yes' + occupant; total injured in accident='None' + no. of occupants in vehicle>1.		0
XIII. Not applicable (0)	For driver, if total # of injured in vehicle=0 & total # of killed in vehicle=0. For right front occupant, if total # of injured=0, & total # killed occupant=0 & total # of occupant >1.		0
XIV. All other cases			M (Missing)

With respect to (1), all else being equal the more rural the state the greater the serious injury rate within belt type. Maryland and Colorado (A+K) rates are consistent with this hypothesis. New York State has a considerably higher police reporting threshold (2) than the other states, namely injury-producing accidents. Again, all else being equal, their serious injury rates within belt type would be expected to be somewhat elevated.

Reporting errors (3) are indeterminable from this data. Definitional differences (4) clearly exist. Fatal injuries are reasonably unambiguous. However, there are a variety of definitions for A-injuries. For example, Maryland defines A-injury as "incapacitating", Alabama as "visible signs of injury, as bleeding wound or distorted member, or had to be carried from scene", and North Carolina as "injury obviously serious enough to prevent the person injured from performing his normal activities for at least one day beyond the day of the accident" while New York has no explicit definition of A-injuries.

In order to derive a KABCO scale for New York State data and to capture information on non-injured occupants, the translation scheme detailed in Figure 2.1 was used. New York accident data utilizes a three-dimensional injury code consisting of victim's injury status (e.g., semi-conscious), type of complaint (e.g., minor bleeding), and location of injury (e.g., chest). For injury status I - VIII, the translation scheme developed by New York was utilized; for injury status IX - XIV, the translation scheme was developed for this study and primarily separates out non-injured occupants. Thus, for New York, it would appear that there would be definitional differences as well as differences in reporting thresholds.

Notwithstanding these differences, there is a reasonably similar and consistent reduction in the (A+K)-injury rates from state to state for the automatic Rabbits compared to the conventional Rabbits.

With respect to occupant characteristics for the states where there is adequate data (NY, NC, MD and CO), there are only relatively minor differences both among states and between belt system types. The majority of occupants fall in the 21-35 year old age range (see Table 2.9) with the distributions by belt type (automatic vs. manual) perhaps surprisingly similar across states.

The majority (approximately 55 percent) of the occupants in each state are male with no clear differences between belt types across states (see Table 2.10). Either the occupancy rate is lower in Colorado or right front seat occupants are less likely to be reported on than in the other three states (see Table 2.11). Excepting Colorado, it would appear that there are approximately

Table 2.9

Occupant age by Rabbit belt type by state.

State	Belt Type	Age <21	21-35	36-55	56+	Total N	[%]
NY	Manual %	19.1	48.9	24.2	7.8	3611	[80.0]
	Automatic %	17.8	48.9	24.8	8.5	910	[20.0]
NC	Manual %	23.4	53.2	17.7	5.7	1423	[77.0]
	Automatic %	28.0	43.5	20.2	8.2	425	[23.0]
MD	Manual %	22.3	52.1	18.9	6.7	1756	[74.7]
	Automatic %	18.3	47.1	27.6	7.0	595	[25.3]
CO	Manual %	17.7	59.5	18.1	4.7	1288	[74.7]
	Automatic %	15.8	58.0	18.6	7.6	436	[25.3]
AL*	Manual %	22.0	59.7	11.0	7.3	82	[86.3]
	Automatic %	38.4	30.8	30.8	0.0	13	[13.7]
SC*	Manual %	27.8	33.3	33.3	5.6	18	[85.7]
	Automatic %	33.3	33.3	33.3	0.0	3	[14.3]
Total		2128	5427	2270	735	10560	
%		20.1	51.4	21.5	7.0		

*Based on drivers only.

Table 2.10

Occupant sex by Rabbit belt type by state

State	Belt Type	Occupant* Sex Male	Female	Total N	[%]
NY	Manual %	54.9	45.1	3664	[80.0]
	Automatic %	57.2	42.8	918	[20.0]
NC	Manual %	54.8	45.2	1416	[77.0]
	Automatic %	59.6	40.4	423	[23.0]
MD	Manual %	57.2	42.8	1768	[74.8]
	Automatic %	54.4	45.6	597	[25.2]
CO	Manual %	54.1	45.9	1302	[74.9]
	Automatic %	52.2	47.8	437	[25.3]
AL*	Manual %	58.6	41.4	732	[78.8]
	Automatic %	57.9	42.1	197	[21.2]
SC*	Manual %	57.9	42.1	190	[78.5]
	Automatic %	55.8	44.2	52	[21.5]
Total %		6514 55.7	5182 44.3	11696	

*Based on drivers only.

Table 2.11

Occupant seating position* by Rabbit belt type by state.

State	Belt Type	Seating Position: Driver	Seating Position: Right Front Seat	Total: N	Total: [%]
NY	Manual %	76.9	23.1	3670	[80.0]
	Automatic %	78.6	21.4	918	[20.0]
NC	Manual %	74.7	25.3	1580	[77.2]
	Automatic %	74.3	25.7	467	[22.8]
MD	Manual %	81.5	18.5	1967	[75.2]
	Automatic %	81.0	19.0	648	[24.8]
CO	Manual %	92.3	7.7	1554	[74.9]
	Automatic %	94.2	5.8	521	[25.1]
	Total	9123	2202	11325	
	%	80.6	19.4		

*Seating position is not available for Alabama and South Carolina.

1.3 occupants per crash (assuming that there always is a driver) regardless of the type of belt system.

Although more will be said with respect to the study data in Chapter 5, this concludes the comparison and discussion of certain key variables both across states and between belt systems within states. Prior to presenting the results of the analyses in Chapter 4, a brief discussion of the methodological components will be given in Chapter 3.

CHAPTER 3. STATISTICAL METHODOLOGY

The purpose of this section is to discuss the methodology adopted in the analysis of the state data. The methodology essentially consists of the following three steps: (1) select variables for control, (2) fit linear models to the data to obtain smoothed injury rate estimates, and (3) based on these injury rate estimates, obtain estimates of the components of the injury rate reduction that are attributable to restraint usage rate differences, to system differences, and to sample variation. These steps are explained in greater detail below.

Variable Selection

In order to compare the injury experiences of front seat, outboard occupants of automatic restraint system Volkswagen Rabbits to those in the manual restraint system Volkswagen Rabbits, it is necessary to do this on as similar a basis as possible. That is, they should be compared under similar crash circumstances. This can reasonably be accomplished by controlling for those factors that indicate significant differences between the two types of Rabbits in the data sample. Normally the number of these confounding factors that one can actually control for is limited by the available sample size. Consequently, certain criteria are needed to determine which of these factors will be used as controls. The selection procedure is outlined below; for a more extensive treatment of this procedure, see Chi (1980a).

A. <u>Listing of potential confounding factors</u>

A list of potential confounding factors is determined by the relevancy of these factors to the problem at hand, and by the availability of information on these variables. From this list, a number of factors are then selected by the following selection or screening procedure.

B. <u>Calculation of relevant statistics</u>

At each stage of the selection procedure, the following statistics are calculated for each candidate variable V, or the joint distribution of V with variables already selected from preceding stages:

1. $T_1 = \chi^2(V \times \text{RABBIT TYPE})$: The Pearson Chi-square statistic for measuring the association between V and RABBIT TYPE, the associated degrees of freedom, and the corresponding p-value.

2. $T_2 = \chi^2(V \times \text{INJURY})$: The Pearson Chi-square statistic for measuring the association between V and INJURY, the associated degrees of freedom, and the corresponding p-value.

C. The screening criterion

Both statistics T_1 and T_2 must be significant in order for a variable to be further considered since, if the association between V and RABBIT TYPE as measured by T_1 is not significant, then its exclusion will not affect the effectiveness estimate regardless of the significance of the association between V and INJURY (i.e., T_2). On the other hand, if the association between V and INJURY is not significant, then the inclusion of V as a control will not contribute significantly to the reduction of variation in injury.

D. The selection process

Among the variables that meet the above screening criterion, select the one with the largest T_1/d.f. and T_2/d.f. statistics. If other variables have T_1/d.f. and T_2/d.f. of about the same magnitude, then the one that is the least ambiguously defined is preferred. The process is then repeated using the joint classification of the first variable selected and each of the remaining candidate variables vs. RABBIT TYPE and INJURY, respectively. If sample size or T_1/d.f. and T_2/d.f. suggests that repetition of the preceding steps is not warranted, then additional variables with significant T_1/d.f. and T_2/d.f. may be selected at this stage.

Thus, a certain amount of subjectivity is involved in the selection process. The procedure repeats itself after each selection has been made and will be terminated if one of the following situations occurs.

(i) No more relevant factors are available for consideration;

(ii) The statistics T_1/d.f. and/or T_2/d.f. are not significant for any of the remaining variables; or

(iii) Sample size limits the usefulness of further screening.

Categorical Data Modeling

Introduction

In many analyses, the independent and dependent variables are categorical in nature. Grizzle, Starmer, and Koch (1969) proposed a general method (GSK) for analyzing such data by weighted least squares procedures. This method requires first the definition of a response function which is generally a function of proportions (probabilities) in a contingency table generated by the dependent variable(s) and a set of independent variables determined by the aforementioned selection scheme. The choice of a response function normally depends on substantive interests.

The response function once defined is treated as a dependent variable, and linear regression models are fitted by the method of weighted least squares, which properly accounts for the inherent variability in these quantities.

If the final model proves adequate, one obtains the predicted values of the dependent variable and estimates of its variance-covariance matrix. Based on these estimates, estimates for the values of other functions of the dependent variable(s) and their associated variance-covariance matrix are derived.

The GSK Method

Assuming that the dependent variable (which may be multivariate) and a set of independent variables (e.g., factors selected as controls) have been identified for a given problem, a basic contingency table, as shown in Table 3.1, is generated where the subpopulations are determined by the factor

Table 3.1
Theoretical (s × r) contingency table

Subpopulation	Response Category 1	2	... r	Row Total
1	n_{11}	$n_{12}\cdots$	n_{1r}	n_1
2	n_{21}	$n_{22}\cdots$	n_{2r}	n_2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
s	n_{s1}	$n_{s2}\cdots$	n_{sr}	n_s

level combinations of the independent variables, and the response categories are the levels of the dependent variable. For example, in Table 4.20 the subpopulations are determined by (NBVEH × RABBIT TYPE), and the response categories are determined by (Restraint Usage × INJAK).

Based on the assumption that the subpopulations are independent and can be characterized by multinomial distributions with probabilities p_{ij} representing the probability of observing response j in subpopulation i, then p_{ij} can be estimated by

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \quad , \quad j=1,2,\ldots,r-1 \quad , \quad i=1,2,\ldots,s$$

with $\hat{p}_{ir} = 1 - \sum_{j=1}^{r-1} \hat{p}_{ij}$. The corresponding variance-covariance matrix $\underset{\sim}{V}$ can be estimated by

$$\mathrm{Var}[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_{ij}} \qquad j=1,2,\ldots,r-1$$

$$\mathrm{Cov}[\hat{p}_{ij}\hat{p}_{ik}] = -\frac{\hat{p}_{ij}\ \hat{p}_{ik}}{n_i} \qquad j\neq k$$

Because the samples from different subpopulations are assumed to be independent, the covariation across rows should be zero, i.e.

$$\mathrm{Cov}[\hat{p}_{ij}\hat{p}_{kj}] = 0 \qquad i\neq k$$

The relationship between variation among the proportions can be investigated by fitting linear regression models to the vector $\underset{s\times(r-1)}{\underset{\sim}{P}}$. This aspect of the methodology can be characterized by writing

$$\underset{s\times(r-1)}{\underset{\sim}{P}} = \underset{s\times t}{\underset{\sim}{X}}\ \underset{t\times(r-1)}{\underset{\sim}{\beta}}$$

where $\underset{s\times t}{\underset{\sim}{X}}$ is a design matrix of full rank t, and $\underset{\sim}{\beta}$ is the t×(r-1) matrix of parameters (or effects) to be estimated. The estimated $\underset{\sim}{\beta}$ are determined by

$$\underset{t\times(r-1)}{\hat{\underset{\sim}{\beta}}} = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1}\ \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{P}$$

where $\underset{\sim}{X}'$ is the matrix transpose of $\underset{\sim}{X}$ and $\underset{t\times(r-1)}{\hat{\underset{\sim}{\beta}}}$ minimizes the quadratic function

$$\chi^2_W = [\underset{\sim}{P} - \underset{\sim}{X}\underset{\sim}{\beta}]'\underset{\sim}{V}^{-1}\ [\underset{\sim}{P} - \underset{\sim}{X}\underset{\sim}{\beta}]$$

The variance-covariance matrix of $\hat{\underset{\sim}{\beta}}$ is consistently estimated by

$$\underset{\sim}{V}_{\beta} = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-1} .$$

Justification for a linear regression model is provided by the residual sum of squares χ^2_W. If the model fits well, χ^2_W is distributed approximately as χ^2 with $[s(r-1)-t(r-1)] = (s-t)(r-1)$ degrees of freedom.

When an appropriate model has been determined, statistical tests of significance involving $\hat{\beta}$ may be performed by analogous standard multiple regression procedures. Linear hypotheses are formulated as

$$H_0 = \underset{u\times t}{C} \underset{t\times(r-1)}{\beta} = \underset{u\times(r-1)}{0}$$

where $\underset{u\times t}{C}$ is a known contrast matrix, and tested using the statistic

$$\chi^2_{WC} = \hat{\beta}'C' [C(X'V^{-1}X)^{-1}C']^{-1} C\hat{\beta}$$

which is approximately distributed as χ^2 with $u(r-1)$ degrees of freedom.

Successive uses of the goodness of fit test and the significance tests specified by C represent ways of partitioning the model components into specific sources of variation. In this context, the C matrix reflects the amount the residual sum of squares, χ^2_W, would increase if one reduced the model by substituting in the conditions described by H_0: $C\beta = 0$. This partitioning of total variance into specific sources represents a statistically valid analysis of variance for proportions.

Finally, predicted values corresponding to any specific model can be calculated from

$$\hat{P} = X\hat{\beta} = X(X'V^{-1}X)^{-1} X'V^{-1}P$$

and corresponding variance estimates can be obtained from the diagonal elements of

$$\hat{V}(\hat{P}) = X(X'V^{-1}X)^{-1}X' \quad .$$

Predicted values for other functions of P and their associated variances can also be obtained using appropriate functions of P and V.

This type of linear model analysis can be undertaken by using a computer program (GENCAT) written and used extensively in the Biostatistics Department of the University of North Carolina in Chapel Hill. The program (GENCAT) was used in this study. It should be noted that in cases where cell sizes $n_{ij} = 0$, it was necessary to replace them by 0.5 in order to prevent $\underset{\sim}{V}$ from being singular. For further details, see Freeman, Koch, Hunter and Lacey (1975), Appendices B and C.

A Decomposition of the Injury Rate Reduction

The Federal Motor Vehicle Safety Standard 208: Occupant Crash Protection is based on the premise that restraint systems when used offer significant occupant protection in terms of fatality and/or injury reduction. Consequently, systems that have the potential of increasing the restraint usage rate will have the potential of reducing fatality and/or injury. Thus, in analyzing the effectiveness of the VW Rabbit automatic restraint system relative to the manual restraint system, it was deemed important to determine whether there was an increase in restraint usage rates for occupants of Rabbits with automatic restraint systems, whether there was a reduction in injury rates, and, when there was a reduction in the injury rates, how much of it was attributable to the usage rate increase, how much of it was due to system differences, and how much of it was due to other factors (i.e., sample variation).

It is the purpose of this section to demonstrate that, after properly controlling for the most relevant confounding factors, the overall serious injury rate reduction can be decomposed into three components. The first component is attributable to restraint usage rate differences, the second component to system differences, and the third component to sample variations.*

More specifically, for a given factor level combination ℓ defined by the factors under control, consider the following basic table cross-classifying RABBIT TYPE by RESTRAINT USAGE by INJURY.

For simplicity of discussion, consider the following symbolic representations. The second equality in each line follows easily from Table 3.2.

*The phrase 'sample variation' refers to variation between the two types of VW Rabbits other than system differences and differences in system usage rates. In the ideal situation, 'sample variation' should be at a minimum. In practice, this component is minimized as much as possible by controlling for significant confounding factors.

Table 3.2

Distribution of sample by Rabbit type, restraint use, and injury level.

Rabbit Type	Restraint Not Used		Restraint Used		Total
	Uninjured	Injured	Uninjured	Injured	
Manual	$n_{\ell 11}$	$n_{\ell 12}$	$n_{\ell 13}$	$n_{\ell 14}$	$n_{\ell 1}$
	$p_{\ell 11}$*	$p_{\ell 12}$	$p_{\ell 13}$	$p_{\ell 14}$	
Automatic	$n_{\ell 21}$	$n_{\ell 22}$	$n_{\ell 23}$	$n_{\ell 24}$	$n_{\ell 2}$
	$p_{\ell 21}$	$p_{\ell 22}$	$p_{\ell 23}$	$p_{\ell 24}$	

*$p_{\ell ij} = n_{\ell ij}/n_{\ell i}$

R_ℓ^M = Manual restraint usage rate = $p_{\ell 13} + p_{\ell 14}$

R_ℓ^A = Automatic restraint usage rate = $p_{\ell 23} + p_{\ell 24}$

I_ℓ^M = Injury rate for occupants of VW's with manual restraints = $p_{\ell 12} + p_{\ell 14}$

I_ℓ^A = Injury rate for occupants of VW's with automatic restraints = $p_{\ell 22} + p_{\ell 24}$

$I_{R,\ell}^M$ = Injury rate given that manual restraint was used = $\dfrac{p_{\ell 14}}{p_{\ell 13} + p_{\ell 14}}$

$I_{R,\ell}^A$ = Injury rate given that automatic restraint was used = $\dfrac{p_{\ell 24}}{p_{\ell 23} + p_{\ell 24}}$

$I_{\bar{R},\ell}^M$ = Injury rate given that manual restraint was not used = $\dfrac{p_{\ell 12}}{p_{\ell 11} + p_{\ell 12}}$

$I_{\bar{R},\ell}^A$ = Injury rate given that automatic restraint was not used = $\dfrac{p_{\ell 22}}{p_{\ell 21} + p_{\ell 22}}$

The overall difference in injury rates between Manual and Automatic restraint systems is then given for each factor level combination ℓ by $(I_\ell^M - I_\ell^A)$ which algebraically can be shown to be equal to

$$(I_\ell^M-I_\ell^A) = (R_\ell^M-R_\ell^A)(I_{R,\ell}^M-I_{\bar{R},\ell}^M) + R_\ell^A(I_{R,\ell}^M-I_{R,\ell}^A) + (1-R_\ell^A)(I_{\bar{R},\ell}^M-I_{\bar{R},\ell}^A) \qquad (3.1)$$

Now taking the stratum weighted average of these injury differences, one obtains

$$\begin{aligned}\sum_\ell W_\ell(I_\ell^M-I_\ell^A) &= \sum_\ell W_\ell(R_\ell^M-R_\ell^A)(I_{R,\ell}^M-I_{\bar{R},\ell}^M) \\ &+ \sum_\ell W_\ell R_\ell^A(I_{R,\ell}^M-I_{R,\ell}^A) + \sum_\ell W_\ell(1-R_\ell^A)(I_{\bar{R},\ell}^M-I_{\bar{R},\ell}^A)\end{aligned} \qquad (3.2)$$

It is important to point out the physical interpretation of Equation (3.1) (or Equation (3.2)). For each stratum ℓ, $(I_{R,\ell}^M - I_{\bar{R},\ell}^M)$ is the reduction in the injury rate for occupants of VW Rabbits with manual restraints as a result of manual restraint usage. Hence the component of $(I_\ell^M - I_\ell^A)$ attributed to restraint usage rate differences is given by the first term $(R_\ell^M - R_\ell^A)(I_{R,\ell}^M - I_{\bar{R},\ell}^M)$, in Equation (3.1) (or Equation (3.2)).

Similarly, $(I_{R,\ell}^M - I_{R,\ell}^A)$ is the difference in injury rates for occupants of VW Rabbits with automatic restraints relative to occupants of VW Rabbits with manual restraints when both types of systems were used. This difference represents the system differences. Consequently, the component of $(I_\ell^M - I_\ell^A)$ which is attributable to system differences is given by the second term, $R_\ell^A\ (I_{R,\ell}^M - I_{R,\ell}^A)$ in Equation (3.1) (or Equation (3.2)) which is just $(I_{R,\ell}^M - I_{R,\ell}^A)$ adjusted by the automatic restraint system usage rate (R_ℓ^A).

Finally, $(I_{\bar{R},\ell}^M - I_{\bar{R},\ell}^A)$ is the difference in injury rates between occupants of VW Rabbits with automatic restraints and occupants of VW Rabbits with manual restraints when both types of restraint systems were <u>not</u> in use. This difference represents sample variation because, when both systems were not used, the corresponding injury rates should be approximately the same. Hence, the component of the overall difference in injury rates, $(I_\ell^M - I_\ell^A)$, which is attributable to sample variations is given by the last term $(1-R_\ell^A)(I_{\bar{R},\ell}^M - I_{\bar{R},\ell}^A)$ in Equation (3.1) which is simply the difference $(I_{\bar{R},\ell}^M - I_{\bar{R},\ell}^A)$ adjusted by the automatic restraint system non-usage rate $(1 - R_\ell^A)$.

If both sample variation and system differences are not significant, then nearly all of the overall injury rate reduction ($I_\ell^M - I_\ell^A$) can be attributed to the difference in the restraint system usage rates. If such is not the case, then one cannot attribute all of the injury reduction to the difference in the restraint system usage rates and Equation (3.2) provides the means for estimating these individual components.

Thus, the injury rates and restraint usage rates as well as each of the three components in Equation (3.2) can be estimated using the GSK method discussed in the preceding section.

CHAPTER 4. ANALYSIS OF SIX STATES' RABBIT ACCIDENT DATA

The statistical methodology outlined in the preceding chapter is applied to the VW Rabbit accident data from each of the four states: New York, North Carolina, Maryland and Colorado. Due to certain limitations in the accident information, only relatively simple analyses are carried out for the Alabama and South Carolina data. The results are discussed in the order of variable selection, GSK estimation procedure, and a study on the effect of missing restraint usage information for each of the four primary states.

Analysis of NEW YORK Data

Variable Selection

Table 4.1 provides a list of variables that are considered as potential confounding factors. The selection procedure is essentially that described in Chapter 3.

For each variable in Table 4.1, the Pearson Chi-square statistics for the two-way tables Variable × RABBIT TYPE and Variable × INJAK were calculated where

$$\text{INJAK} = \begin{cases} 0, & \text{if Injury} = \text{B, C, or O} \\ 1, & \text{if Injury} = \text{A or K} \end{cases}$$

These statistics are presented in Table 4.2. Only variables that have both Pearson Chi-square statistics significant were considered. Among these variables, the one that had the highest Chi-square statistic per degree of freedom with respect to INJAK was selected. In the present case, Restraint Usage had the largest Chi-square statistic with respect to both RABBIT TYPE and INJAK. Thus, it was selected as the first variable to be included in the analysis.

After having selected Restraint Usage, the procedure was repeated by calculating the statistics $T = \chi^2$((Restraint Usage × V) × RABBIT TYPE) and $T = \chi^2$((Restraint Usage × V) × INJAK) for the remaining variables. Table 4.3 provides a summary of these statistics for some of the more significant variables. This table shows that, after controlling for Restraint Usage, NBVEH (Number of Vehicles) was the most significant variable followed by VEHWTO (Vehicle Weight of the Other Car).

Table 4.1
A list of variables considered as potential controls
(New York)

Characteristics	Variable	Levels	Description of Levels
Accident	Accident year	5	1975,1976,1977,1978,1979
	Accident type	4	Car/car, car/fixed object, car/others, non-collision
	NBVEH (Number of vehicles)	2	Single vehicle, multi-vehicle
	Light condition	5	Daylight, dawn, dusk, dark-road lighted, dark-road unlighted
	Road surface condition	4	Dry, wet, muddy/slush, snow/ice
	Type of road system	11	Interstate, state highway, city road, town road, municipal street, Parkway, Thruway, Northway, other limited access highway, unknown roadway, non-traffic
Vehicle	Model year	5	1975,1976,1977,1978,1979
	VEHWTO (vehicle weight of other vehicle)	5	0, under 2001, 2001-3000, 3001-4000, over 4000
	Impact area	4	Front, left, right, rear
	Extent of damage	6	0,1,2,3,4,5 (=severe)
	Tow	2	Towed, not towed
Occupant	Sex	2	Male, female
	Age group	6	Under 16, 16-20, 21-25, 26-35, 36-55, above 55
	Seating position	2	Driver, right front
	Restraint usage	2	Used, not used
	Ejection	2	Yes, no

Table 4.2

Pearson Chi-square statistics for (variable × RABBIT TYPE) and (variable × INJAK) (New York)

Variable	RABBIT TYPE (Excluding unknown restraint usage cases)	INJAK (Excluding unknown restraint usage cases)	RABBIT TYPE (Including unknown restraint usage cases)	INJAK (Including unknown restraint usage cases)
Accident year	3.0 (4) 0.55* 0.8	13.4 (4) 0.01 3.4	2.4 (4) 0.67 3.1	12.2 (4) 0.02 3.1
Accident type	2.7 (3) 0.45 0.9	71.8 (3) † 23.9	6.7 (3) 0.08 2.2	94.9 (3) † 31.6
NBVEH (Number of vehicles)	0.4 (1) 0.56 0.4	55.8 (1) † 55.8	0.8 (1) 0.37 0.8	72.6 (1) † 72.6
Light condition	2.2 (4) 0.70 0.6	20.3 (4) † 5.1	2.0 (4) 0.73 0.5	17.2 (4) 0.01 4.3
Road surface condition	2.8 (3) 0.42 0.9	1.8 (3) 0.62 0.6	1.2 (3) 0.75 0.4	3.0 (3) 0.39 0.0
Type of road system	16.8(10) 0.08 1.7	10.5(10) 0.40 1.1	22.3(10) 0.01 2.2	19.2(10) 0.04 1.9
Model year	26.8 (4) 0.001 6.7	8.3 (4) 0.08 2.1	22.7 (4) 0.001 5.7	12.0 (4) 0.02 3.0
VEHWTO (Veh. wt. of other car)	9.3 (4) 0.05 2.3	56.2 (4) † 14.0	7.9 (4) 0.10 2.0	73.4 (4) † 18.4
Impact area	1.2 (3) 0.76 0.4	21.1 (3) 0.001 7.0	1.8 (3) 0.62 0.6	17.4 (3) 0.006 11.7
Extent of damage	4.2 (5) 0.53 0.8	231.5 (5) † 46.3	4.9 (5) 0.43 1.0	260.2 (5) † 52.1
Tow	0.3 (1) 0.59 0.3	87.1 (1) † 87.1	0.2 (1) 0.64 0.2	115.2 (1) † 115.2
Sex	1.6 (1) 0.20 1.6	3.8 (1) 0.05 3.8	1.6 (1) 0.21 1.6	6.3 (1) 0.01 6.3
Age group	1.9 (5) 0.86 0.4	1.0 (5) 0.96 0.2	2.3 (5) 0.72 0.6	1.3 (5) 0.94 0.3
Seating position	0.8 (1) 0.38 0.8	1.0 (1) 0.33 1.0	1.3 (1) 0.25 1.3	0.3 (1) 0.57 0.3
Restraint usage	240.7 (1) † 240.7	27.2 (1) † 27.2	N.A.	N.A.
Ejection	1.0 (1) 0.31 1.0	204.5 (1) † 204.5	0.8 (1) 0.38 0.8	204.1 (1) † 204.1

* χ^2 = 3.0 (d.f. = 4) p-value = 0.55 χ^2/d.f. = 0.8

† p-value < 0.001

N.A. = not applicable

Table 4.3

Pearson Chi-square statistics for ((Restraint usage × V) × RABBIT TYPE) and ((Restraint usage × V) × INJAK)
(New York)

Variable (V)	(Restraint Usage × V) × RABBIT TYPE	(Restraint Usage × V) × INJAK
NBVEH (Number of vehicles)	241.4 (3)* 80.5	85.8 (3) 28.6
Type of road system	269.3 (20) 13.5	47.5 (20) 2.4
Model year	287.4 (9) 31.9	39.4 (9) 4.4
VEHWTO (Vehicle weight of other vehicle)	265.2 (9) 39.5	86.5 (9) 9.6
Impact area	133.0 (7) 19.0	48.2 (7) 6.9

*χ^2 = 241.4 (d.f. = 3)
χ^2/d.f. = 80.5

An examination of the χ^2 values in Table 4.3 indicates that further repetition of the screening procedure will not be useful, hence the procedure is terminated by selecting both NBVEH and VEHWTO at this stage.

Estimation Procedure

The analysis conducted in this section is based upon the variables Restraint Usage, NBVEH, and VEHWTO selected in the preceding section.

From Table 4.2, one notes that the χ^2(Restraint usage × RABBIT TYPE) = 240.7 with 1 degree of freedom which is significantly higher than all the other values. This indicates that Restraint Usage Rates between manual and automatic restraint systems are significantly different. Furthermore, χ^2(Restraint Usage × INJAK) = 27.21 with 1 degree of freedom which implies that Restraint Usage Rates are significantly different between the injured and the uninjured occupants. Consequently, the focus of the ensuing analysis will be on estimating the restraint usage rates, the overall (A+K)-injury rates for occupants of VW Rabbits with manual and automatic restraint systems, and the three components of the overall injury rate reduction which will provide simultaneously an estimate for the component due to differential restraint usage rates, an estimate for the component due to system differences, and an estimate for the component due to sample variations that remain unaccounted for after controlling for NBVEH and VEHWTO.

These estimates can be obtained by applying the GSK method to the multi-dimensional contingency Table 4.4 generated by the cross-classification NBVEH × VEHWTO × RABBIT TYPE × (RESTRAINT USAGE × INJAK).

Table 4.4

Data for VW manual and automatic restraint comparison relative to (A+K)-injury characterization (New York)

NBVEH	VEHWTO*	Rabbit Type	Restraint Not Used Uninjured	Restraint Not Used Injured	Restraint Used Uninjured	Restraint Used Injured	Margin Total	Stratum Total (W_ℓ)
1	None	M	327	56	144	15	542	672
		A	48	10	69	3	130	[0.16]
2+	Under 2001	M	641	42	284	7	974	1246
		A	117	7	145	3	272	[0.29]
	2001-3000	M	346	24	162	5	537	648
		A	54	3	51	3	111	[0.15]
	3001-4000	M	641	43	255	4	943	1169
		A	72	5	142	7	226	[0.27]
	Over 4000	M	276	18	108	3	405	526
		A	50	2	67	2	121	[0.12]
Total			2572	210	1427	52		4261

*Weight of the other vehicle.

In Table 4.4, for each stratum represented by a given factor level combination of (NBVEH × VEHWTO), the (Restraint Usage × INJAK) distributions, assumed to be multinomial, are contrasted between manual and automatic restraint type. The corresponding stratum weight [W_ℓ] is given in the last column.

First a saturated model was fit to the observed injury rates $\underset{\sim}{P}$ via the linear model $\underset{\sim}{P} = \underset{\sim}{X}_s\underset{\sim}{\beta}$, where $\underset{\sim}{P}$, $\underset{\sim}{\beta}$(the parameter vector), and $\underset{\sim}{X}_s$ (the saturated design matrix) are given below. The first column of the design matrix

$$\underset{\sim}{P} = \begin{bmatrix} 0.603 & 0.103 & 0.266 \\ 0.369 & 0.077 & 0.531 \\ 0.658 & 0.043 & 0.292 \\ 0.430 & 0.026 & 0.533 \\ 0.644 & 0.045 & 0.302 \\ 0.486 & 0.027 & 0.459 \\ 0.680 & 0.046 & 0.270 \\ 0.319 & 0.022 & 0.628 \\ 0.681 & 0.044 & 0.267 \\ 0.413 & 0.017 & 0.554 \end{bmatrix} \quad \underset{\sim}{X}_s = \begin{bmatrix} 1&1&0&0&0&1&1&0&0&0 \\ 1&1&0&0&0&0&0&0&0&0 \\ 1&0&1&0&0&1&0&1&0&0 \\ 1&0&1&0&0&0&0&0&0&0 \\ 1&0&0&1&0&1&0&0&1&0 \\ 1&0&0&1&0&0&0&0&0&0 \\ 1&0&0&0&1&1&0&0&0&1 \\ 1&0&0&0&1&0&0&0&0&0 \\ 1&0&0&0&0&1&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0 \end{bmatrix} \quad \underset{\sim}{\beta} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \\ \beta_6 \\ \beta_7 \\ \beta_8 \\ \beta_9 \\ \beta_{10} \end{bmatrix}$$

represents the overall mean injury rate, the second column represents the main effect for NBVEH, the next three columns represent the main effects for VEHWTO (4 levels), the sixth column represents the effect of RABBIT TYPE, and the last four columns represent, respectively, the interaction effects for NBVEH × RABBIT TYPE and VEHWTO × RABBIT TYPE. The i-th parameter, $\underset{\sim}{\beta}_i$, corresponds to the i-th column of $\underset{\sim}{X}$.

A series of models were then successively fitted where the design matrix $\underset{\sim}{X}$ at each stage was obtained by deleting all columns of the immediately preceding design matrix that corresponded to non-significant main effects and/or interaction terms. Once the final design matrix $\underset{\sim}{X}_f$ had been obtained (i.e., when a model was obtained which provided an adequate fit to the data), then the model coefficient estimates $\hat{\underset{\sim}{\beta}}$ are given by

$$\hat{\underset{\sim}{\beta}} = (\underset{\sim}{X}_f'\underset{\sim}{V}^{-1}(\underset{\sim}{X}_f)^{-1}(\underset{\sim}{X}_f'\underset{\sim}{V}^{-1}\underset{\sim}{P})$$

$$\underset{\sim}{V}(\hat{\underset{\sim}{\beta}}) = (\underset{\sim}{X}_f'\underset{\sim}{V}^{-1}\underset{\sim}{X}_f)^{-1}$$

where $\underset{\sim}{V}$ is the covariance matrix for $\underset{\sim}{P}$. The predicted values for $\underset{\sim}{P}$ can then be obtained from

$$\hat{\underset{\sim}{P}} = \underset{\sim}{X}_f\hat{\underset{\sim}{\beta}}$$

with covariance matrix

$$\underset{\sim}{V}(\hat{\underset{\sim}{P}}) = \underset{\sim}{X}_f\ (\underset{\sim}{X}_f'\underset{\sim}{V}^{-1}\underset{\sim}{X}_f)^{-1}\underset{\sim}{X}_f'$$

The estimates for Restraint Usage Rates, for Overall Injury Rates, and for the three terms on the right side of Equation (3.2) can then be derived from $\hat{P}$.

Figure 4.1

Observed ($\underset{\sim}{P}$) and predicted ($\hat{\underset{\sim}{P}}$) multinomial probabilities final design matrix $\underset{\sim}{X}_f$, and model coefficients $\hat{\underset{\sim}{\beta}}$ (New York)

NBVEH	VEHWTO*	Rabbit Type	Multinomial Probability: Restraint Not Used, Uninjured $p_{i1}(\hat{p}_{i1})$	Restraint Not Used, Injured $p_{i2}(\hat{p}_{i2})$	Restraint Used, Uninjured $p_{i3}(\hat{p}_{i3})$	Restraint Used, Injured $p_{i4}(\hat{p}_{i4})$	Final Design Matrix $\underset{\sim}{X}_f$	Model Coefficients β
1	None	M	0.603 (0.602)	0.103 (0.102)	0.266 (0.270)	0.028**	1 1 0 1 0	β_1
		A	0.369 (0.379)	0.077 (0.081)	0.531 (0.509)	0.023	1 1 0 0 0	β_2
2+	1 - 2000	M	0.658 (0.660)	0.043 (0.044)	0.292 (0.288)	0.007	1 0 0 1 0	β_3
		A	0.430 (0.437)	0.026 (0.023)	0.533 (0.528)	0.011	1 0 0 0 0	β_4
	2001- 3000	M	0.644 (0.660)	0.045 (0.044)	0.302 (0.288)	0.009	1 0 0 1 0	β_5
		A	0.486 (0.437)	0.027 (0.023)	0.459 (0.528)	0.027	1 0 0 0 0	5×3
	3001- 4000	M	0.680 (0.680)	0.046 (0.046)	0.270 (0.270)	0.004	1 0 1 1 1	
		A	0.319 (0.319)	0.022 (0.022)	0.628 (0.628)	0.031	1 0 1 0 0	
	Over 4000	M	0.681 (0.660)	0.044 (0.044)	0.267 (0.288)	0.007	1 0 0 1 0	
		A	0.413 (0.437)	0.017 (0.023)	0.554 (0.528)	0.017	1 0 0 0 0	

*Weight of the other vehicle.

**Since each subpopulation is assumed to have a multinomial distribution, the sum across each row is 1. Hence for the purpose of modeling, one of the four proportions can be omitted. In this analysis, the last column of $\hat{\underset{\sim}{P}}$ is omitted. Consequently, $\hat{P}_{i4} = 1-\sum_j \hat{P}_{ij}$

Figure 4.1 (continued)

Interpretation of Model Coefficients	Model Coefficients	Coefficient Estimates	Standard Deviations
Overall Mean	$\underset{\sim}{\beta}_1$	[0.437, 0.023, 0.528]	[0.020, 0.006, 0.020]
Main Effects: NBVEH	$\underset{\sim}{\beta}_2$	[-0.058, 0.058,-0.018]	[0.021, 0.012, 0.020]
V_3 (VEHWTO=3001-4000)	$\underset{\sim}{\beta}_3$	[-0.118,-0.001, 0.101]	[0.037, 0.012, 0.038]
R (Rabbit Type)	$\underset{\sim}{\beta}_4$	[0.224, 0.021,-0.240]	[0.022, 0.008, 0.022]
Interaction: $V_3 \times R$	$\underset{\sim}{\beta}_5$	[0.138, 0.002,-0.118]	[0.041, 0.014, 0.041]

Test Statistics for H_0: $\underset{\sim}{\beta}_i = \underset{\sim}{0}$

Model Coefficients	χ^2	d.f.	p-Value
$\underset{\sim}{\beta}_1$	39963.8	3	< 0.001
$\underset{\sim}{\beta}_2$	32.7	3	< 0.001
$\underset{\sim}{\beta}_3$	11.5	3	0.009
$\underset{\sim}{\beta}_4$	128.5	3	< 0.001
$\underset{\sim}{\beta}_5$	13.6	3	0.004

Goodness-of-fit Statistic

Goodness-of-fit Statistic: χ^2 due to error = 5.89 with 15 degrees of freedom and p = 0.98

The final design matrix $\underset{\sim}{X}_f$, the observed and predicted multinomial probabilities, the estimated model coefficients and the goodness-of-fit statistic are all summarized in Figure 4.1.

The χ^2 goodness-of-fit statistic for the final model is 5.89 with 15 degrees of freedom and with an associated p-value of 0.98. This indicates that the final model fits the data very well.

The estimated model coefficients show that NBVEH($\underset{\sim}{\beta}_2$) and V_3(VEHWTO = 3001-4000 vs. others)($\underset{\sim}{\beta}_3$) are significant confounding factors. The significance of RABBIT TYPE ($\underset{\sim}{\beta}_4$) implies that the overall (Restraint usage × INJAK) distributions are significantly different between the two Rabbit types. Furthermore, the significance of the interaction (V_3 × RABBIT TYPE) implies that the differences in Rabbit types are differentially more important in the stratum defined by (NBVEH = 2+, VEHWTO = 3001-4000).

The significant difference in the (Restraint usage × INJAK) distribution between the two Rabbit types is mainly attributable to restaint usage rate differences. Estimates for the restraint usage rates, overall (A+K)-injury rates, the three components on the right side of Equation (3.2), and the corresponding differences and effectiveness can be obtained from the final model. These estimates are all summarized in Table 4.5.

These figures show, among other things, that the presence of automatic restraint systems results in almost a doubling of the restraint usage rate in accidents and a corresponding decrease in serious injuries by a factor of about one-fifth. However, here one also obtains estimates for three components given in the decomposition formula (Equation 3.2) for the overall injury rate reduction. More specifically, the estimates show that the component attributed to restraint usage rate differences is 1.22% which is statistically significant at $\alpha = 0.05$, the component attributed to system differences is -0.22% which is not statistically significant, and that the component attributed to sample variations is 0.09% which is also not statistically significant.

The overall effectiveness of the automatic restraint system in reducing (A+K)-injury is estimated to be 17.27% which is not statistically significant. However, the effectiveness of the automatic restraint system attributed to the increased automatic restraint usage rate is 19.27% which is statistically significant at $\alpha = 0.05$. The reason for the smaller overall effectiveness estimate for the automatic restraint system is apparently due to the negative component due to the restraint system which cancels out part of the positive effectiveness of the system due to the increased automatic restraint usage rate.

Table 4.5
Estimates for restraint usage rates, (A+K)-injury rates, components comprising the overall (A+K)-injury rate reduction and effectiveness
(New York)

	Estimates (%) (Standard Error) Manual	Automatic	Difference (%)* Manual - Automatic (Standard Error)	Effectiveness (%) Relative to Manual (Standard Error)
Restraint Usage Rate	28.96 (1.67)	57.25 (1.84)	28.29† (0.78)	97.71† (7.81)
(A+K)-Injury Rate	6.33 (0.41)	5.24 (0.72)	1.09 (0.81)	17.27 (12 30)
Components of Variation in (A+K)-Injury Rate Differences:				
Attributed to Restraint Usage Rate Differences			1.22† (0.23)	19.27† (3.34)
Attributed to System Differences			-0.22 (0.56)	-3.48 (8.85)
Attributed to Sample Variations			0.09 (0.58)	1.48 (7.92)

Absolute value of the difference.
†Statistically significant at $\alpha = 0.10$.

<u>The Effect of Deleting Cases with Missing Restraint Usage Information.</u>

From Table 4.6, one can observe that restraint usage information is missing from approximately 16 percent of the cases. In this section, the potential effect of the deletion of these cases will be examined from the following three different angles.

First, Table 4.6 shows that the proportion of cases with missing restraint usage information is not significantly different between the two types of Rabbit restraint systems. This indicates that the cases with missing restraint usage information are not overrepresented in one particular type of restraint system.

Table 4.6
Availability of Rabbit type by restraint usage information
(New York)

RABBIT Type	Known Restraint Usage	Unknown Restraint Usage	Total
Manual	3401 (84.71%)	614 (15.29%)	4015 [79.57%]
Automatic	860 (83.41%)	171 (16.59%)	1031 [20.43%]
Total	4261 (84.44%)	785 (15.56%)	5046

$X^2 = 1.04$, d.f. = 1 with $p = 0.31$

Secondly, Table 4.2 contrasts the Pearson Chi-square statistics based on the total population to the Pearson Chi-square statistics based on the subpopulation with known restraint usage information. The deletion of unknown restraint usage cases does not seem to change appreciably the Chi-square statistics which implies that their deletion does not tend to distort the underlying association between these variables and RABBIT TYPE and also INJAK.

Thirdly, Table 4.7 compares the injury rates between the manual and the automatic restraint systems based on the total population, while Table 4.8 provides the same comparison based on the subpopulation with known restraint usage information. These two tables together show that, by deleting the cases

Table 4.7
(Rabbit Type × INJAK) distribution for total population
(New York)

Total Population	INJAK 0	INJAK 1	Total
Manual	3773 (93.97%)	242 (6.03%)	4015 [79.57%]
Automatic	983 (95.34%)	48 (4.66%)	1031 [20.43%]
Total	4756 (94.25%)	290 (5.75%)	5046

Table 4.8

(Rabbit Type × INJAK) distribution for the subpopulation with known restraint usage information (New York)

Known Restraint Usage	INJAK 0	INJAK 1	Total
Manual	3184 (93.62%)	217 (6.38%)	3401 [79.82%]
Automatic	815 (94.77%)	45 (5.23%)	860 [20.18%]
Total	3999 (93.85%)	262 (6.15%)	4261

with unknown restraint usage information, the serious injury rate for occupants of manual restraint system Rabbits increases from 6.03 percent to 6.38 percent, a 0.35 percent increase, while the injury rate for occupants of automatic restraint system Rabbits increases from 4.66 percent to 5.23 percent, a 0.57 percent increase. This suggests that the subsequent effectiveness estimate will be on the conservative side since the deletion of these unknown restraint usage cases decreases the observed injury rate difference from 1.37 (= 6.03 - 4.66) percent to 1.15 (= 6.38 - 5.23) percent.

With these observations, one concludes that the overall effect on the resulting estimates of the deletion of cases with unknown restraint usage will be minimal. Furthermore, the effectiveness estimates will tend to be on the conservative side.

Analysis of NORTH CAROLINA Data

Variable Selection.

Table 4.9 is a list of variables considered as potential controls. Variables that are identical to those appearing in Table 4.1 for New York State are similarly defined. Overall, the two lists are quite comparable.

Again for each variable in Table 4.9, the Pearson Chi-square statistics for the two-way tables Variable × RABBIT TYPE and Variable × INJAK were calculated where INJAK is defined as before. These statistics are presented in Table 4.10. Among the variables Model Year, VEHWTO, and Restraint Usage which have

Table 4.9

A list of variables considered as potential controls
(North Carolina)

Characteristics	Variable	Levels	Level Description
Accident	Means of involvement	7	Ran off road, hit fixed object, hit non-fixed object, car vs. car, car vs. truck/bus, more than two vehicles involved, other
	NBVEH (Number of vehicles)	2	Single vehicle, multi-vehicle
	Road surface condition	4	Dry, wet, muddy, snowy/icy
Vehicle	Model year	5	1975, 1976, 1977, 1978, 1979
	VEHWTO (weight of other vehicle)	5	0, 1-2000, 2001-3000 3001-4000, over 4000
	Region of impact	5	Front, right side, left side, rear, unspecified
	TAD (vehicle damage) severity	8	0, 1, 2, 3, 4, 5, 6, 7 (= severe)
	Vehicle drivability	2	Drivable, not drivable
Occupant	Sex	2	Male, female
	Age group	6	Under 16, 16-20, 21-25, 26-35, 36-55, over 55
	Race	2	White, non-white
	Restraint usage	2	Used, not used

significant χ^2 values with respect to both RABBIT TYPE and INJAK, Restraint Usage is again the most significant variable. Thus, it is the first variable to be included in the analysis.

Again having selected Restraint Usage, the procedure is repeated by calculating the statistics $T_1 = \chi^2((\text{Restraint Usage} \times V) \times \text{RABBIT TYPE})$ and $T_2 = \chi^2((\text{Restraint Usage} \times V) \times \text{INJAK})$ for the remaining variables. Table 4.11 is a summary of these statistics for the more significant variables.

NBVEH has the most significant χ^2 values with respect to both RABBIT TYPE and INJAK. Thus it is the second variable to be selected. Due to sample size restriction, the procedure is terminated after including the variable VEHWTO, which is the second-most significant variable in Table 4.11. The variable TAD severity is not considered for two reasons. First, its Chi-square statistic

Table 4.10

Pearson Chi-Square statistics for (VARIABLE × RABBIT TYPE) and (VARIABLE × INJAK) (North Carolina)

Variable	RABBIT TYPE (Excluding unknown restraint usage)	INJAK (Excluding unknown restraint usage)	RABBIT TYPE (Including unknown restraint usage)	INJAK (Including unknown restraint usage)
Means of involvement	6.9 (6) 0.33* 1.1	68.0 (6) † 11.3	6.5 (6) 0.37 1.1	66.7 (6) † 11.1
NBVEH (Number of vehicles)	0.3 (1) 0.61 0.3	43.6 (1) † 43.6	0.3 (1) 0.57 0.3	44.6 (1) † 44.6
Road surface condition	0.8 (3) 0.84 0.3	0.3 (3) 0.96 0.1	0.5 (3) 0.91 0.2	0.3 (3) 0.96 0.1
Model year	29.0 (4) † 7.3	4.4 (4) 0.35 1.1	36.5 (4) † 9.1	7.7 (4) 0.10 1.9
VEHWTO (Vehicle wt. of other vehicle)	12.3 (4) † 3.1	10.9 (4) 0.03 2.7	10.0 (4) 0.04 2.5	15.7 (4) † 3.9
Region of impact	4.3 (4) 0.36 1.1	30.1 (4) † 7.5	3.8 (4) 0.43 1.0	36.2 (4) † 9.1
TAD severity	8.4 (7) 0.30 1.2	185.9 (7) † 26.6	10.1 (7) 0.18 1.5	238.2 (7) † 34.0
Drivability	2.3 (1) 0.13 2.3	96.0 (1) † 96.0	2.6 (1) 0.11 2.6	104.6 (1) † 104.6
Sex	2.6 (1) 0.11 2.6	1.0 (1) 0.33 1.0	3.0 (1) 0.08 3.0	1.5 (1) 0.23 1.5
Age	16.0 (5) 0.01 3.2	3.7 (5) 0.60 0.7	15.3 (5) 0.01 3.1	4.2 (5) 0.52 0.8
Race	2.4 (1) 0.12 2.4	2.4 (1) 0.13 2.4	2.0 (1) 0.16 2.0	2.6 (1) 0.10 2.6
Restraint usage	130.8 (1) † 130.8	5.9 (1) 0.02 5.9	N.A.	N.A.

*$\chi^2 = 6.9$ (d.f. = 6) p-value = 0.33
χ^2/d.f. = 1.1

†p-value < 0.001
N.A. = Not applicable

Table 4.11

Pearson Chi-Square statistics for (RESTRAINT USAGE × V) × RABBIT TYPE and (RESTRAINT USAGE × V) × INJAK (North Carolina)

Variable	(Restraint Usage × V) × RABBIT Type	(Restraint Usage × V) × INJAK
Means of involvement	156.1 (13)* 12.0	80.7 (13) 6.2
NBVEH (Number of vehicles)	136.6 (3) 45.5	56.2 (3) 18.7
Road surface condition	74.3 (7) 10.6	10 3 (7) 1.5
Model year	178.8 (9) 19.4	22.2 (9) 2.5
VEHWTO (Weight of other vehicle)	155.8 (9) 17.3	57.9 (9) 6.4
Region of impact	123.0 (9) 13.7	38.4 (9) 4.3
Drivability	9.8 (3) 9.3	96.4 (3) 32.1
TAD severity	130.1 (13) 10.0	190.0 (13) 14.6
Sex	36.2 (3) 12.0	3.3 (3) 1.1
Age	159.7 (9) 17.7	11.0 (9) 1.2

*χ^2 = 156.1 (d.f. = 13)
χ^2/d.f. = 12.0

with respect to RABBIT TYPE is not as significant as VEHWTO, and secondly, it has eight categories whereas VEHWTO has only five categories, which is important due to sample size restrictions.

Estimation Procedure.

To obtain estimates for Restraint Usage Rates, Overall Serious Injury Rates, and for the three terms on the right side of Equation (3.2), the GSK method is applied to the multi-dimensional contingency table generated by the cross-classification NBVEH × VEHWTO × RABBIT TYPE × (Restraint Usage × INJAK) where each subpopulation (row) is assumed to follow a multinomial distribution. (see Table 4.12).

Table 4.12
NBVEH × VEHWTO × RABBIT TYPE × (RESTRAINT USAGE × INJAK)
(North Carolina)

NBVEH	VEHWTO*	Rabbit Type	Restraint Not Used Uninjured	Restraint Not Used Injured	Restraint Used Uninjured	Restraint Used Injured	Margin Total	Stratum Total (W_ℓ)
1	None	M	144	27	22	1	194	256
		A	30	2	29	1	62	[0.17]
2+	1-2000	M	142	3	23	0	168	224
		A	31	2	22	1	56	[0.15]
	2001-3000	M	214	7	42	0	263	322
		A	33	0	26	0	59	[0.22]
	3001-4000	M	272	11	70	1	354	484
		A	82	2	45	1	130	[0.33]
	Over 4000	M	122	10	27	0	159	192
		A	13	0	17	3	33	[0.13]
Total			1083	64	323	8		1478

*Weight of the other vehicle

First a saturated model was fit to the observed injury rates $\underset{\sim}{P}$ via the linear model $\underset{\sim}{P} = \underset{\sim}{X}\underset{\sim}{\beta}$ where $\underset{\sim}{\beta}$, the parameter vector, and $\underset{\sim}{X}_s$ the saturated design matrix are given on page 44 . A series of models were then successively fitted. The final design matrix $\underset{\sim}{X}_f$, the observed and predicted multinomial probabilities, the estimated model coefficients and the goodness-of-fit statistic are summarized in Figure 4.2.

Figure 4.2

Observed ($\underset{\sim}{P}$) and predicted ($\hat{\underset{\sim}{P}}$) multinomial probabilities. final design matrix $\underset{\sim}{X}_f$, and model coefficients (North Carolina)

Multinomial Probability

NBVEH	VEHWTO	Rabbit Type	Restraint Not Used Uninjured $p_{i1}(\hat{p}_{i1})$	Restraint Not Used Injured $p_{i2}(\hat{p}_{i2})$	Restraint Used Uninjured $p_{i3}(\hat{p}_{i3})$	Restraint Used Injured $p_{i4}(\hat{p}_{i4})$	Final Design Matrix $\underset{\sim}{X}_f$	Model Coefficients $\hat{\underset{\sim}{\beta}}$
1	None	M	0.742 (0.742)	0.139 (0.139)	0.113 (0.113)	0.005*	1 0 1 1 0	β_1
		A	0.484 (0.506)	0.032 (0.026)	0.468 (0.448)	0.016	1 0 0 0 0	β_2
2+	1-2000	M	0.840 (0.813)	0.018 (0.027)	0.136 (0.155)	0.006	1 0 1 0 0	β_3
		A	0.554 (0.506)	0.036 (0.026)	0.393 (0.448)	0.018	1 0 0 0 0	β_4
	2001-3000	M	0.811 (0.813)	0.027 (0.027)	0.159 (0.155)	0.004	1 0 1 0 0	β_5
		A	0.541 (0.506)	0.016 (0.026)	0.426 (0.448)	0.016	1 0 0 0 0	5 × 3
	3001-4000	M	0.768 (0.768)	0.031 (0.031)	0.198 (0.198)	0.003	1 1 1 0 1	
		A	0.631 (0.631)	0.015 (0.015)	0.346 (0.346)	0.008	1 1 0 0 0	
	Over 4000	M	0.763 (0.813)	0.063 (0.027)	0.169 (0.155)	0.006	1 0 1 0 0	
		A	0.382 (0.506)	0.029 (0.026)	0.500 (0.448)	0.088	1 0 0 0 0	

*Since each subpopulation is assumed to have a multinomial distribution, the sum across each row is 1. Hence for the purpose of modeling, one of the four proportions can be omitted. In this analysis, the last column of $\underset{\sim}{P}$ is omitted. Consequently, $\hat{\underset{\sim}{p}}_{i4} = 1-\sum_{j} p_{ij}$.

Figure 4.2 (continued)

Interpretation of Model Coefficients	Model Coefficients	Coefficient Estimates	Standard Deviations
Overall Mean	$\underset{\sim}{\beta}_1$	[0.506, 0.026, 0.448]	[0.034, 0.011, 0.034]
Main Effects:			
V_3 (VEHWTO=3001-4000)	$\underset{\sim}{\beta}_2$	[0.125,-0.011,-0.102]	[0.054, 0.015, 0.054]
R (RABBIT TYPE)	$\underset{\sim}{\beta}_3$	[0.307, 0.001 -0.293]	[0.037, 0.013, 0.037]
Interaction:			
NBVEH × R	$\underset{\sim}{\beta}_4$	[-0.070, 0.112,-0.042]	[0.035, 0.026, 0.027]
V_3 × R	$\underset{\sim}{\beta}_5$	[-0.169, 0.015, 0.145]	[0.061, 0.019, 0.056]

Test Statistics for $H_0 : \underset{\sim}{\beta}_i = \underset{\sim}{0}$

Model Coefficients	X^2	d.f.	p-Value
$\underset{\sim}{\beta}_1$	10868.31	3	$p < 0.01$
$\underset{\sim}{\beta}_2$	5.93	3	0.12
$\underset{\sim}{\beta}_3$	70 45	3	$p < 0.01$
$\underset{\sim}{\beta}_4$	19.99	3	$p < 0.01$
$\underset{\sim}{\beta}_5$	7.97	3	0.05

Goodness-of-fit Statistic: X^2 due to error = 10.56 with 15 degrees of freedom and p - 0.7[illegible]

The χ^2 goodness-of-fit statistic for the final model is 10.56 with 1[illegible] degrees of freedom and with a corresponding p-value of 0.78 indicating an adequate fit.

The model coefficient estimates show that the overall effect of RABBIT TYPE (β_3) is significant. This is to say that, overall, the (RESTRAINT USAGE × INJAK) distributions are significantly different between the two Rabbit types. The significance of V_3 (VEHWTO = 3000-4000 vs others) (β_2) indicates that its overall importance as a confounding factor is marginal. However, the significance of the interaction V_3 x RABBIT TYPE (β_5) shows that for the stratum defined by (NBVEH = 2+, VEHWTO= 3001-4000), there are significant differences in the (Restraint Usage × INJAK) distributions over and above those accounted for by RABBIT TYPE (β_3). The same is true for the stratum defined by (NBVEH = 1) in view of the significance of the interaction NBVEH × RABBIT TYPE (β_4).

The desired estimates and their associated standard errors are then derived as before from $\underset{\sim}{P} = \underset{\sim}{X}_f \hat{\underset{\sim}{\beta}}$, and $\underset{\sim}{V}(\hat{\underset{\sim}{P}}) = \underset{\sim}{X}_f(\underset{\sim}{X}_f' \underset{\sim}{V}^{-1} \underset{\sim}{X}_f)^{-1} \underset{\sim}{X}_f'$ where $\underset{\sim}{V}$ is the covariance matrix associated with $\underset{\sim}{\beta}$. These estimates are summarized in Table 4.13.

Table 4.13

Estimates for restraint usage rates, (A+K)-Injury rates, overall injury rate reduction, three components comprising the overall injury rate reduction and effectiveness (North Carolina)

	Estimates (%) (Standard Error) Manual	Automatic	Difference (%)* (Manual - Automatic) (Standard Error)	Effectiveness (%) (Relative to Manual) (Standard Error)
Restraint Usage rate	16.63 (1.10)	43.08 (2.66)	26.45† (2.87)	159.07† (23.42)
Injury rate	5.21 (0.65)	3.83 (1.05)	1.38 (1.23)	26.38 (22.06)
Components of Variation in (A+K)-Injury Rate Differences				
Attributed to restraint usage rate differences			0.85† (0.45)	16.33† (8.40)
Attributed to system differences			-0.35 (0.87)	-6.81 (17.12)
Attributed to sample variations			0.88 (0.90)	16.87 (16.62)

*Absolute value of the difference.
†Statistically significant at $\alpha = 0.10$.

The figures above show, among other things, that the presence of automatic restraint systems results in more than a doubling of the restraint usage rate in accidents and a decrease in serious injuries by a factor of over 25 percent. Estimates for the three components of Equation (3.2) show that the component attributed to a restraint usage rate increase is 0.85 percent which is statistically significant at $\alpha = 0.05$ level while the component attributed to sample variations is 0.88 percent and the component attributed to system differences is -0.35 percent, both of which are not statistically significant.

The overall effectiveness of the automatic restraint system in reducing (A+K)-injury is estimated to be 26.38 percent which is not statistically significant. However, the component of the serious injury rate variation attributed to increased usage of automatic restraints is 16.33 percent which is statistically significant at $\alpha = 0.10$ level.

The estimate of 0.88 percent for the component attributed to sample variations is relatively large in comparison to the first component attributed to restraint usage rate differences. This suggests that the remaining sample variations after controlling for NBVEH and VEHWTO are still substantial.

The Effect of Deleting Cases with Missing Restraint Usage Information

Table 4.14 indicates that about 10 percent of the cases have missing restraint usage information. The potential effect of their deletion from the preceding analysis will be examined below

First, Table 4.14 shows that the proportion of cases with missing restraint usage information is not significantly different between the two types of Rabbit restraint systems. This implies that the cases with unknown restraint usage information are not overrepresented in one particular type of restraint system.

Table 4.14

RABBIT TYPE × RESTRAINT USAGE information availability
(North Carolina)

RABBIT TYPE	Known Restraint Usage	Unknown Restraint Usage	Total
Manual	1426 (90.25%)	154 (9.75%)	1580 [77.19%]
Automatic	425 (91.01%)	42 (8.99%)	196 [22.81%]
Total	1851 (90.43%)	196 (9.57%)	2047

$\chi^2 = 0.24$, d.f. = 1 with p = 0.63

Next, Table 4.10 compares the Pearson Chi-square statistics based on the total population to the Pearson Chi-square statistics based on the subpopulation with known restraint usage information. The deletion of unknown restraint usage cases again does not seem to change the Chi-square statistic significantly which implies that their deletion does not tend to distort the underlying relationships between these variables and RABBIT TYPE, and also INJAK.

Finally, Table 4.15 compares the injury rates between the manual and the automatic restraint systems based on the total population, and Table 4.16 provides an analogous comparison based on the subpopulation with known restraint usage information. These two tables together show that, by deleting the cases

Table 4.15

(RABBIT TYPE × INJAK) based on total population
(North Carolina)

Total Population	INJAK 0	INJAK 1	Total
Manual	1505 (95.25%)	75 (4.75%)	1580 [77.19%]
Automatic	451 (96.57%)	16 (3.43%)	467 [22.81%]
Total	1956 (95.55%)	91 (4.45%)	2047

Table 4.16

(RABBIT TYPE × INJAK) based on subpopulation
with known restraint usage information
(North Carolina)

Known Restraint Usage	INJAK 0	INJAK 1	Total
Manual	1361 (95.44%)	65 (4.56%)	1426 [77.04%]
Automatic	410 (96.47%)	15 (3.53%)	425 [22.96%]
Total	1771 (95.68%)	80 (4.32%)	1851

with unknown restraint usage information, the injury rates for occupants of manual restraint systems decreases from 4.75 percent to 4.56 percent, while the injury rate for occupants of automatic restraint systems increases from 3.43 percent to 3.53 percent. Together this suggests that the subsequent effectiveness estimate will be on the conservative side. The deletion of these cases with unknown restraint usage information decreases the injury rate reduction from 1.32 (=4.75 - 3.43) percent to 1.03 (=4.56 - 3.53) percent.

Thus, one can reasonably conclude that deleting unknown restraint usage cases has a minimal effect on the resulting estimates. Indeed, the effectiveness estimates will tend to be on the conservative side.

Analysis of MARYLAND Data

Variable Selection.

The list of variables considered as potential controls for the Maryland analysis is given in Table 4.17. For each variable in this table, the Pearson Chi-square statistics for the two-way tables Variable × RABBIT TYPE and Variable × INJAK are calculated where INJAK is defined as follows:

$$\text{INJAK} = \begin{cases} 0, & \text{if Injury = No injury, possible injury, or non-incapacitating injury} \\ 1, & \text{if Injury = Incapacitating injury or fatal} \end{cases}$$

These statistics are given in Table 4.18. Again restraint usage is the only variable with significant χ^2-values with respect to RABBIT TYPE and INJAK Thus, it is the first variable to be included in the subsequent analysis.

After having selected Restraint Usage, the procedure is repeated by calculating: $T_1 = \chi^2$((Restraint Usage × V) × RABBIT TYPE) and $T_2 = \chi^2$((Restraint Usage × V) × INJAK) for each of the remaining variables. Table 4.19 provides a summary of these statistics for some of the more significant variables.

The variable Ejection has the most significant χ^2 values. However, this variable is not very informative since less than 1 percent of the occupants in the file were ejected. Hence, NBVEH is the second variable selected because it is the next most significant variable. The procedure is terminated at this stage and no other variables are selected because inclusion of additional variable(s) would result in many empty cells in the subsequent contingency table due to relatively low injury frequencies.

4.3.2 Estimation Procedure.

Again to obtain estimates for restraint usage rates, overall serious injury rates, and for the three terms on the right side of Equation (3.2), the GSK method is applied to the multi-dimensional contingency table generated by the cross-classification NBVEH × RABBIT TYPE × (Restraint Usage × INJAK) where each subpopulation (row) is assumed to follow a multinomial distribution (see Table 4.20).

Table 4.17

A list of variables considered as potential controls

(Maryland)

Characteristics	Variable	Levels	Description of Levels
Accident	Accident year	5	1975, 1976, 1977, 1978, 1979
	Accident type	12	Other motor vehicle in transport, parked MV, MV on other roadway, pedestrian, pedacycle, other pedestrian conveyance, animal, railway, train, fixed object other object, overturned, other non-collision
	NBVEH (Number of vehicles)	2	Single vehicle, multi-vehicle
	Road surface condition	4	Dry, wet, muddy, snowy/icy
Vehicle	Model year	5	1975, 1976, 1977, 1978, 1979
	VEHWTO (Weight of vehicle)	5	0, 1-2000, 2001-3000, 3001-4000, over 4000
	Vehicle damage severity	4	Disabling, functional, other vehicle damage, no damage
	Damage area	4	Front, left side, right side rear
	Strike	2	Striking, struck
Occupant	Sex	2	Male, female
	Age	6	Under 16, 16-20, 21-25, 26-35, 36-55, above 55
	Ejection	2	Ejected (full, partial), not ejected
	Restraint usage	2	Used, not used

Table 4.18

Pearson Chi-square statistics for (VARIABLE × RABBIT TYPE)
and (VARIABLE × INJAK)
(Maryland)

Variable	RABBIT TYPE	INJAK	RABBIT TYPE	INJAK
	(Excluding Unknown Restraint Usage Cases)		(Including Unknown Restraint Usage Cases)	
Accident year	27.4 (4)* † 6.8	5.1 (4) 0.28 1.3	28.4 (4) † 7.1	3.5 (4) 0.48 0.9
Accident type	34.2(11) † 3.1	78.1(11) † 7.1	37.5(11) † 3.4	84.7(11) † 7.7
Number of vehicles	0.1 (1) 0.93 0.1	15.6 (1) † 15.6	0.2 (1) 0.90 0.2	22.9 (1) † 22.9
Road surface condition	16.1 (3) † 5.4	2.1 (3) 0.54 0.7	17.3 (3) † 5.8	3.5 (3) 0.32 1.2
Model year	49.0 (4) † 12.3	1.4 (4) 0.85 0.4	51.1 (4) † 12.8	0.8 (4) 0.94 0.2
Vehicle weight of other car	0.8 (4) 0.94 0.2	18.7 (4) † 4.7	1.6 (4) 0.80 0.4	20.6 (4) † 5.2
Damage area	2.5 (3) 0.47 0.8	6.5 (3) 0.09 2.2	2.6 (3) 0.45 0.9	8.5 (3) 0.04 2.8
Sex	1.2 (1) 0.28 1.2	0.1 (1) 0.71 0.1	1.4 (1) 0.24 1.4	0.0 (1) 0.97 0.0
Age	21.3 (5) † 4.3	7.1 (5) 0.21 1.4	21.5 (5) † 4.3	6.7 (5) 0.24 1.4
Ejection	1.3 (1) 0.26 1.3	86.1 (1) † 86.1	1.8 (1) 0.18 1.8	66.1 (1) † 66.1
Strike	0.5 (1) 0.50 0.5	6.6 (1) 0.01 6.6	0.0 (1) 0.92 0.0	11.3 (1) † 11.3
Vehicle damage severity	6.2 (3) 0.18 2.1	85.2 (3) † 28.4	7.2 (3) 0.12 2.4	111.2 (3) † 37.1
Restraint usage	180.0 (1) † 180.0	5.9 (1) † 5.9	N.A.	N.A.

*χ^2 = 27.4 (d.f. = 4)
χ^2/d.f. = 6.8

†p-value < 0.001
N.A. = not applicable

Table 4.19

Pearson Chi-square statistics for (RESTRAINT USAGE × V) × RABBIT TYPE and (RESTRAINT USAGE × V) × INJAK (Maryland)

Variable	(Restraint Usage × V) × RABBIT Type	(Restraint Usage × V) × INJAK
Accident year	204.4 (9)* 22.7	48.4 (9) 5.4
Accident type	209.0 (22) 9.5	124.9 (22) 5.7
NBVEH (number of vehicles)	180.6 (3) 60.2	24.5 (3) 8.2
Road surface condition	185.2 (7) 26.5	11.9 (7) 1.7
Model year	231.2 (9) 25.7	10.6 (9) 1.2
VEHWTO (veh. weight of other vehicle)	153.2 (9) 17.0	35.1 (9) 3.9
Vehicle damage severity	181.3 (7) 25.9	101.4 (7) 14.5
Damage area	184.8 (7) 26.4	13.1 (7) 1.9
Strike	176.9 (3) 59.0	12.3 (3) 4.1
Age	198.1 (11) 18.0	17.6 (11) 1.6
Ejection	180.7 (3) 60.2	100.1 (3) 33.4

*χ^2 = 204.4 (d.f. = 9)
χ^2/d.f. = 22.7

Table 4-20

NBVEH × RABBIT TYPE × (RESTRAINT USE × INJAK)
(Maryland)

NBVEH	RABBIT TYPE	Restraint Not Used Uninjured	Restraint Not Used Injured	Restraint Used Uninjured	Restraint Used Injured	Margin Total	Stratum Total (W_ℓ)
1	Manual	93	11	59	2	165	223 [0.10]
	Automatic	15	1	40	2	58	
2+	Manual	863	24	631	13	1531	2052 [0.90]
	Automatic	131	5	381	4	521	
Total		1102	41	1111	21		2275

First a saturated model was fit to the observed injury rates $\underset{\sim}{P}$ using the linear model $\underset{\sim}{P} = \underset{\sim}{X}_s\underset{\sim}{\beta}$ where

$$\underset{\sim}{P} = \begin{bmatrix} 0.563 & 0.067 & 0.358 \\ 0.259 & 0.017 & 0.690 \\ 0.564 & 0.016 & 0.412 \\ 0.251 & 0.010 & 0.731 \end{bmatrix}, \quad \underset{\sim}{X}_s = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}, \quad \underset{\sim}{\beta} = \begin{bmatrix} \underset{\sim}{\beta}_1 \\ \underset{\sim}{\beta}_2 \\ \underset{\sim}{\beta}_3 \\ \underset{\sim}{\beta}_4 \end{bmatrix}$$

The first column of $\underset{\sim}{X}_s$ represents the overall mean injury rate, the next two columns represent the main effects for NBVEH and RABBIT TYPE, and the last column represents the interaction effect for NBVEH × RABBIT TYPE.

A series of models were then successively fitted where the design matrix X at each stage was obtained by deleting all columns of the immediately preceding design matrix that correspond to non-significant main effects and/or to the interaction.

The final design matrix $\underset{\sim}{X}_f$, the observed and predicted multinomial probabilities, the estimated model coefficients and the goodness-of-fit statistic are all summarized in Figure 4.3.

The χ^2 goodness-of-fit statistic is 1.51 with 2 degrees of freedom and a corresponding p-value of 0.68 indicating an adequate fit of the data.

The model coefficient estimates show that the overall effect of RABBIT TYPE ($\underset{\sim}{\beta}_2$) is significant which implies that there is significant difference in the (Restraint Usage × INJAK) distributions between the two Rabbit types. The

Figure 4.3

Observed ($\underset{\sim}{P}$) and predicted ($\hat{\underset{\sim}{P}}$) multinomial probabilities, final design matrix $\underset{\sim}{X}_s$, and model coefficients $\hat{\underset{\sim}{\beta}}$ (Maryland)

NBVEH	Rabbit Type	Multinomial Probability: Restraint Not Used, Uninjured $p_{i1}(\hat{p}_{i1})$	Restraint Not Used, Injured $p_{i2}(\hat{p}_{i2})$	Restraint Used, Uninjured $p_{i3}(\hat{p}_{i3})$	Restraint Used, Injured $p_{i4}(\hat{p}_{i4})$	Final Design Matrix $\underset{\sim}{X}_s$	Model Coefficients $\hat{\underset{\sim}{\beta}}$
1	M	0.563 (0.564)	0.067 (0.067)	0.358 (0.358)	0.012*	1 1 1	$\underset{\sim}{\beta}_1$
	A	0.259 (0.253)	0.017 (0.010)	0.690 (0.729)	0.034	1 0 0	$\underset{\sim}{\beta}_2$
2+	M	0.564 (0.564)	0.016 (0.016)	0.412 (0.412)	0.008	1 1 0	$\underset{\sim}{\beta}_3$
	A	0.251 (0.253)	0.010 (0.010)	0.731 (0.729)	0.008	1 0 0	

*Since each subpopulation is assumed to have a multinomial distribution, the sum across each row is 1. Hence for the purpose of modeling, one of the four proportions can be omitted. In this analysis, the last column of $\underset{\sim}{P}$ is omitted. Consequently, $p_{i4} = 1 - \sum_j p_{ij}$.

Figure 4.3 (continued)

Interpretation of Model Coefficients	Model Coefficients	Coefficient Estimates	Standard Deviations
Overall Mean Proportions	$\underset{\sim}{\beta}_1$	[0.253, 0.010, 0.729]	[0.018, 0.004, 0.018]
Main Effects:			
Rabbit Type (R)	$\underset{\sim}{\beta}_2$	[0.311, 0.006 -0.317]	[0.022, 0.005, 0.022]
Interaction:			
NBVEH x R	$\underset{\sim}{\beta}_3$	[-0.000, 0.051,-0.055]	[0.041, 0.020, 0.039]

Test Statistics for Ho: $\underset{\sim}{\beta}_i = \underset{\sim}{0}$

Model Coefficients	χ^2	d.f.	p-Value
$\underset{\sim}{\beta}_1$	68961.7	3	< 0.01
$\underset{\sim}{\beta}_2$	205.4	3	< 0.01
$\underset{\sim}{\beta}_3$	7.7	3	0.05

Goodness of fit Statistic· χ^2 due to error = 1.51 with 2 degrees of freedom and p = 0.68

significance of the interaction NBVEH × RABBIT TYPE (β_3) indicates that there is an additional difference in the (Restraint Usage × INJAK) distributions between the two Rabbit types in the stratum defined by (NBVEH = 1).

The difference in the (Restraint Usage × INJAK) distributions between the two Rabbit types is again mainly due to the restraint usage rate differences. The effect of the restraint usage rate differences on the overall serious injury rate reduction is examined below.

Table 4.21

Estimates for restraint usage rates, (A+K)-injury rates, overall injury rate reduction, three components comprising the overall injury rate reduction and effectiveness (Maryland)

	Estimates (%) (Standard Error) Manual	Automatic	Difference (%)* (Manual - Automatic) (Standard Error)	Effectiveness (%) Relative to Manual (Standard Error)
Restraint usage rate	41.60 (1.20)	73.71 (1.83)	32.11† (2.18)	77.35† (6.74)
Injury rate	2.95 (0.41)	1.84 (0.56)	1.11† (0.69)	37.61† (20.79)
Components of Variation in (A+K)-Injury Rate Differences:				
Attributed to restraint usage rate differences			0.46† (0.26)	15.55† (8.66)
Attributed to system differences			0.74 (0.55)	25.21 (17.61)
Attributed to sample variation			-0.09 (0.44)	-3.15 (14.88)

*Absolute value of the difference.
†Statistically significant at α = 0.10.

Table 4.21 summarizes the various estimates obtained from the final model. These figures show that the presence of automatic restraint systems again results in almost a doubling of the usage rate and a corresponding decrease in serious injuries by a factor of about one-third. The difference in overall injury serious rates is estimated to be 1.11 percent. The estimates show that the component attributed to restraint usage increase is 0.46 percent, the component attributed to system differences is 0.74 percent, and the component attributed to sample variation is -0.09 percent. The estimate for the first component is statistically significant at α = 0.10, while the estimates for the other two components indicate that they are not significantly different from zero.

The overall effectiveness of the automatic restraint system in reducing serious or fatal injuries is estimated to be 37.61 percent which is statistically significant at $\alpha = 0.10$. Moreover, the effectiveness of the automatic restraint system attributed to restraint usage increase is estimated to be 15.5 percent which is also statistically significant at $\alpha = 0.10$.

The estimate for the component of injury rate reduction attributed to system differences is 0.74 percent which is large compared to the estimate for the first component. This is why the overall effectiveness (37.61%) is much larger than the effectiveness attributed to restraint usage increase (15.5%).

<u>The Effect of Deleting Cases with Missing Restraint Usage Information.</u>

Table 4.22 shows that only about 4 percent of the cases have unknown restraint usage information. As this is an important variable in the analysis, the potential effect of their deletion from the preceding analysis will be examined.

First, Table 4.22 shows that the proportion of cases with missing restraint usage informatin is marginally significantly different between the two types of Rabbit restraint systems.

Table 4.22

RABBIT TYPE × Restraint Usage information availability
(Maryland)

Rabbit Type	Known Restraint Usage	Unknown Restraint Usage	Total
M	1696 (86.22%)	271 (13.78%)	1967 [75.22%]
A	578 (89.20%)	70 (10.80%)	648 [24.78%]
Total	2274 (86.96%)	341 (13.04%)	2615

$X^2 = 3.8$, d.f. = 1 with $p = 0.051$

Next, Table 4.18 compares the Pearson Chi-square statistics based on the total population to the Pearson Chi-square statistics based on the subpopulation with known restraint usage information. Deletion of cases with unknown belt usage again does not tend to distort the underlying relationships between these variables and RABBIT TYPE and also INJAK.

Finally, Table 4.23 compares the injury rates between the manual and the automatic restraint systems based on the total population, and Table 4.24 provides an analogous comparison based on the subpopulation with known restraint usage information. These two tables together show that, by deleting the cases

Table 4.23

(RABBIT TYPE × INJAK) based on total population
(Maryland)

Total Population	INJAK 0	INJAK 1	Total
Manual	1893 (97.13%)	56 (2.87%)	1949 [75.28%]
Automatic	629 (98.28%)	11 (1.72%)	640 [24.72%]
Total	2522 (97.41%)	67 (2.59%)	2589

Table 4.24

(RABBIT TYPE × INJAK) based on subpopulation
with known restraint usage information
(Maryland)

Known Restraint Usage	INJAK 0	INJAK 1	Total
Manual	1646 (97.05%)	50 (2.95%)	1696 [74.58%]
Automatic	567 (98.10%)	11 (1.90%)	578 [25.42%]
Total	2213 (97.32%)	61 (2.68%)	2274

with unknown restraint usage information, the injury rate for occupants of manual restraint systems increases from 2.87 percent to 2.95 percent, while the injury rate for occupants of automatic restraint systems increases from 1.72 percent to 1.90 percent. The deletion of these cases with unknown restraint usage information decreases the injury rate reduction from 1.15 (=2.87 - 1.72) percent to 1.05 (=2.95 - 1.90) percent. This suggests that the subsequent effectiveness estimate will be on the conservative side.

With these various observations, one can again reasonably conclude that the overall effect of the deletion of cases with unknown belt usage will be minimal on the resulting estimates.

Analysis of COLORADO Data

Variable Selection

Table 4-25 contains the available list of variables considered as potential controls for Colorado. Again the Chi-square statistics for this association

Table 4.25
A list of variables considered as potential controls
(Colorado)

Characteristics	Variable	Levels	Description of Levels
Accident	Accident year	5	1975,1976,1977,1978,1979
	NBVEH (Number of vehicles)	2	Single vehicle, multi-vehicle
	Road surface condition	3	Wet, dry, snow/icy
Vehicle	Model year	5	1975,1976,1977,1978,1979
	VEHWTO (Vehicle weight of other vehicle)	5	0, 1-2000, 2001-3000, 3001-4000, Over 4000
	Tow	2	Yes, no
Occupant	Sex	2	Male, female
	Age group	6	Under 16, 16-20, 21-25, 26-35, 36-55, Over 55
	Ejection	2	Ejected, not ejected
	Restraint usage	2	Used, not used

with RABBIT TYPE and INJAK are calculated where INJAK is defined as:

$$\text{INJAK} = \begin{cases} 0 & \text{if Injury = Minor visible injuries, complaint of pain with no visible injuries or no injuries} \\ 1 & \text{if Injury = Fatality, or carried from the scene} \end{cases}$$

These statistics are presented in Table 4.26. Restraint usage is the only variable with significant χ^2 values with respect to both RABBIT TYPE and INJAK. Thus it is the first variable selected.

After having selected RESTRAINT USAGE, the procedure is repeated and the corresponding statistics are given in Table 4.27. In this case, the variable Ejection has the most significant χ^2 values. However, it is not selected because occupants were not ejected in over 99 percent of the cases. Towing is the next most significant variable followed by NBVEH. Due to the size of the sample and the magnitudes of the χ^2 values for the remaining variables further repetition of the procedure was not warranted. Hence, Tow and NBVEH were the two variables selected at this stage. It is of interest that the variable VEHWTO is also significant here but not as significant as Towing or NBVEH.

Estimation Procedure

To obtain estimates for restraint usage rates, overall serious injury rates, and for the three components in the decomposition of the overall (A+K)-injury rate reduction, the GSK method was applied to the multi-dimensional contingency table generated by the cross-classification Tow × NBVEH × RABBIT TYPE × (Restraint Usage × INJAK) where each subpopulation (row) is assumed to follow a multinomial distribution (see Table 4.28).

Generally, occupants of towed vehicles and occupants of non-towed vehicles have different injury experiences. In order to have a better grasp of the underlying relationship, a saturated 2-module model was first fit to the observed injury rates via the linear model $\underset{\sim}{P} = \underset{\sim}{X}_S \underset{\sim}{\beta}$ where

$$P = \begin{bmatrix} 0.554 & 0.259 & 0.179 \\ 0.364 & 0.273 & 0.303 \\ 0.618 & 0.150 & 0.208 \\ 0.377 & 0.105 & 0.456 \\ 0.612 & 0.045 & 0.340 \\ 0.738 & 0.008 & 0.246 \\ 0.698 & 0.010 & 0.291 \\ 0.437 & 0.004 & 0.555 \end{bmatrix}, \quad \underset{\sim}{X}_S = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}, \quad \underset{\sim}{\beta} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \\ \beta_6 \\ \beta_7 \\ \beta_8 \end{bmatrix}$$

Table 4.26

Pearson Chi-square statistics for (VARIABLE × RABBIT TYPE) and (VARIABLE × INJAK) (Colorado)

Variable	Rabbit Type (Excluding unknown Restraint usage cases)	INJAK (Excluding unknown Restraint usage cases)	Rabbit Type (Including unknown restraint usage cases)	INJAK (Including unknown restraint usage cases)
Accident year	4.0 (4) 0.41* 1.0	20.3 (4) † 5.1	3.7 (4) 0.45 0.9	16.2 (4) 0.005 4.1
NBVEH (Number of vehicles)	1.0 (1) 0.32 1.0	55.5 (1) † 55.5	1.5(10) 0.23 1.5	65.4 (1) † 65.4
Road surface condition	0.2 (2) 0.89 0.1	2.4 (2) 0.30 1.2	1.0 (2) 0.61 0.5	4.6 (2) 0.10 2.3
Model year	14.7 (4) 0.01 3.7	5.4 (4) 0.25 1.4	13.9 (4) 0.01 3.5	6.9 (4) 0.14 1.8
VEHWTO (Vehicle weight of other car)	0.87(4) 0.93 0.2	5.3 (4) 0.26 1.3	1.0 (4) 0.91 0.3	5.0 (4) 0.28 1.3
Tow	0.1 (1) 0.77 0.1	177.5 (1) † 177.5	0.4 (1) 0.52 0.4	204.3 (1) † 204.3
Sex	1.2 (1) 0.28 1.2	0.3 (1) 0.60 0.3	0.5 (1) 0.49 0.5	1.2 (1) 0.28 1.2
Age group	8.3 (5) 0.14 1.7	20.4 (5) † 4.1	6.7 (5) 0.25 1.4	24.0 (5) † 4.8
Ejection	0.5 (1) 0.50 0.5	141.2 (1) † 141.2	0.5 (1) 0.50 0.5	141.2 (1) † 141.2
Restraint usage	74.4 (1) † 74.4	20.7 (1) † 20.7	N.A.	N.A.

* $\chi^2 = 4.0$ (d.f. = 4) p-value = 0.41
χ^2/d.f. = 1.0

†p-value < 0.001
N.A. = not applicable

Table 4.27

Pearson Chi-square statistics for (RESTRAINT USAGE × V) × RABBIT TYPE and (RESTRAINT USAGE × V) × INJAK (Colorado)

Variable (V)	(Restraint Usage × V) × RABBIT TYPE	(Restraint Usage × V) × INJAK
Accident year	84.3 (9)* 9.4	53.0 (9) 5.9
NBVEH (Number of vehicles)	76.9 (3) 25.6	85.5 (3) 28.5
Road surface condition	78.6 (5) 15.7	23.0 (5) 4.6
Model year	96.1 (9) 10.7	32.4 (9) 3.6
Tow	78.8 (3) 26.3	205.1 (3) 68.4
VEHWTO (Vehicle weight of other vehicle)	46.7 (9) 5.2	53.7 (9) 6.0
Age	99.3 (11) 9.0	47.8 (11) 4.3
Sex	84.1 (3) 28.0	20.7 (3) 6.9
Ejection	75.7 (2) 37.9	156.0 (2) 78.0

*χ^2 = 84.3 (d.f. = 9)
χ^2/d.f. = 9.4

Table 4.28

Data for VW Rabbit manual and automatic restraint systems comparison relative to (A+K)-injury characterization

Tow	NBVEH	Rabbit Type	Restraint Not Used Uninjured	Restraint Not Used Injured	Restraint Used Uninjured	Restraint Used Injured	Margin Total	Total (%)
Yes	1	M	62	29	20	1	112	145
		A	12	9	10	2	33	(0.09)
	2+	M	202	49	68	8	327	441
		A	43	12	52	7	114	(0.28)
No	1	M	27	2	15	0	44	56
		A	9	0	3	0	12	(0.04)
	2+	M	505	7	211	1	724	962
		A	104	1	132	1	238	(0.60)
Total			964	109	511	20		1604

The design matrix $\underset{\sim}{X}_s$ has been partitioned according to the tow vs. non-tow subpopulation. The first column of $\underset{\sim}{X}_s$ represents the overall mean injury rate for the towed subpopulation, and the next three columns represent the main effects of NBVEH and RABBIT TYPE, and the interaction NBVEH × RABBIT TYPE for this subpopulation. The last four columns represent the corresponding effects for the non-towed subpopulation.

A series of models were then successively fitted. The final design matrix $\underset{\sim}{X}_f$, the observed and predicted multinomial probabilities, the estimated model coefficients, and the goodness-of-fit statistic are summarized in Figure 4.4.

The χ^2 goodness-of-fit statistic is 1.53 with 3 degrees of freedom and a corresponding p-value of 0.67 indicating an adequate fit.

The model parameter estimates show that the main effect NBVEH is a significant confounding factor in both the towed ($\underset{\sim}{\beta}_2$) and the non-towed ($\underset{\sim}{\beta}_5$) subpopulations (see Figure 4.4). The overall effect of RABBIT TYPE ($\underset{\sim}{\beta}_3$,$\underset{\sim}{\beta}_6$) is also significant in the two subpopulations. In the non-towed subpopulation, there is a significant difference in the (Restraint Usage × INJAK) distributions between the two Rabbit types in the case of single-vehicle accidents ($\underset{\sim}{\beta}_7$). Finally, the statistic $\underset{\sim}{\beta}_1 - \underset{\sim}{\beta}_4$ shows that the overall mean injury rates between the towed and the non-towed subpopulations are significantly different suggesting that the partition of the design matrix into modules defined by Tow is appropriate.

Figure 4.4

Observed (P) and predicted ($\hat{P}$) multinomail probabilities, final design matrix $\underset{\sim}{X}_s$, and model coefficients $\underset{\sim}{\beta}$ (Colorado)

Tow	NBVEH	Rabbit Type	Multinomial Probability: Restraint Not Used, Uninjured $p_{i1}(\hat{p}_{i1})$	Restraint Not Used, Injured $p_{i2}(\hat{p}_{i2})$	Restraint Used, Uninjured $p_{i3}(\hat{p}_{i3})$	Restraint Used, Injured $p_{i4}(\hat{p}_{i4})$	Final Design Matrix $\underset{\sim}{X}_s$	Model Coefficients $\underset{\sim}{\beta}$
Yes	1	M	0.554 (0.560)	0.259 (0.268)	0.179 (0.163)	0.009 *	1 1 1 0 0 0 0	$\underset{\sim}{\beta}_1$
		A	0.364 (0.337)	0.273 (0.232)	0.303 (0.380)	0.061	1 1 0 0 0 0 0	$\underset{\sim}{\beta}_2$
	2+	M	0.618 (0.614)	0.150 (0.148)	0.208 (0.214)	0.024	1 0 1 0 0 0 0	$\underset{\sim}{\beta}_3$
		A	0.377 (0 392)	0.105 (0.112)	0.456 (0.431)	0.061	1 0 0 0 0 0 0	$\underset{\sim}{\beta}_4$
No	1	M	0.612 (0.612)	0.045 (0.045)	0.340 (0.340)	0.002	0 0 0 1 1 1 1	$\underset{\sim}{\beta}_5$
		A	0.738 (0.738)	0.008 (0.008)	0.246 (0.246)	0.008	0 0 0 1 1 0 0	$\underset{\sim}{\beta}_6$
	2+	M	0.698 (0.698)	0.010 (0.010)	0.291 (0.291)	0.001	0 0 0 1 0 1 0	$\underset{\sim}{\beta}_7$ (7 x 3)
		A	0.437 (0.437)	0.004 (0.004)	0.555 (0.555)	0.004	0 0 0 1 0 0 0	

* Since each subpopulation is assumed to have a multinomial distribution, the sum across each row is 1. Hence for the purpose of modeling, one of the four proportions can be omitted. In this analysis, the last column of $\underset{\sim}{P}$ is omitted. Consequently, $P_{i4} = 1 - \sum_j \hat{p}_{ij}$

Figure 4.4 (Cont.)

Module	Interpretation of Model Coefficients	Model Coefficients	Coefficient Estimates	Standard Deviations
Tow=Yes	Overall Mean	$\underset{\sim}{\beta}_1$	[0.392, 0.112, 0.431]	[0.041, 0.027, 0.041]
	Main Effects			
	NBVEH (N_y)	$\underset{\sim}{\beta}_2$	[-0.055, 0.120, -0.050]	[0.047, 0.040, 0.039]
	Rabbit Type (R_y)	$\underset{\sim}{\beta}_3$	[0.222, 0.036, -0.217]	[0.046, 0.032, 0.044]
Tow=No	Overall Mean Proportion	$\underset{\sim}{\beta}_4$	[0.437, 0.004, 0.555]	[0.032, 0.004, 0.032]
	Main Effects			
	NBVEH (N_n)	$\underset{\sim}{\beta}_5$	[0.301, 0.004, -0.309]	[0.130, 0.026, 0.127]
	Rabbit Type (R_n)	$\underset{\sim}{\beta}_6$	[0.261, 0.005, -0.263]	[0.036, 0.006, 0.036]
	Interaction $N_n \times R_n$	$\underset{\sim}{\beta}_7$	[-0.386, 0.032, 0.357]	[0.150, 0.041, 0.147]

Test Statistics for Ho: $\underset{\sim}{\beta}_i = \underset{\sim}{0}$

Model Coefficients	χ^2	d.f.	p-Value
$\underset{\sim}{\beta}_1$	2196.9	3	< 0.01
$\underset{\sim}{\beta}_2$	10.4	3	0.02
$\underset{\sim}{\beta}_3$	33.8	3	< 0.01
$\underset{\sim}{\beta}_4$	56406.0	3	< 0.01
$\underset{\sim}{\beta}_5$	5.9	3	0.12
$\underset{\sim}{\beta}_6$	53.8	3	< 0.01
$\underset{\sim}{\beta}_7$	6.9	3	0.08
$\beta_1 - \underset{\sim}{\beta}_4$	27.0	2	< 0.01

Goodness-of-fit Statistic: χ^2 due to error = 1.53 with 3 degrees of freedom and p = 0.67

The differences in the (Restraint Usage × INJAK) distributions between the two Rabbit Types are again mainly attributable to restraint usage rate differences. Estimates for restraint usage rates, overall serious injury rates, the three components on the right side of Equation (3.2), and the corresponding differences and effectiveness are summarized in Table 4.29.

Table 4.29

Estimates for restraint usage rates, (A+K)-injury rates, overall injury rate reduction, three components comprising the overall injury rate reduction and effectiveness (Colorado)

	Estimates (%) (Standard Error) Manual	Automatic	Difference (%)* (Manual – Automatic) (Standard Error)	Effectiveness (%) (Relative to Manual) (Standard Error)
Restraint Usage Rate	29.37 (2.24)	46.13 (3.97)	16.76 † (4.55)	57.07 † (18.00)
Injury Rate	5.07 (0.98)	4.12 (1.17)	0.95 (1.47)	18.78 (27.02)
Components of Variation in (A+K) - Injury Rate Differences:				
Attributed to Restraint Usage Rate Differences			0.70 † (0.36)	13.87 † (7.81)
Attributed to System Differences			-0.57 (0.84)	-11.31 (16.79)
Attributed to Sample Variation			0.82 (1.30)	16.22 (23.63)

*Absolute value of the difference
†Statistically significant at $\alpha = 0.10$.

These figures show that the presence of automatic restraint systems again increases the usage rate by about one and a half times, and decreases the injury rate by a factor of about one-fifth. The difference in the overall serious injury rate is estimated to be 0.95 percent. The estimates show that the component of the overall injury rate reduction attributed to restraint usage rate differences is 0.70 percent, the component attributed to system differences is -0.57 percent, and the component attributed to sample variation is 0.82 percent. The estimate for the belt usage component is statistically significant at $\alpha = 0.10$, while the estimates for the other two components are not statistically significantly different from zero.

The estimate of 0.82 percent for the third component is relatively large in magnitude when compared to the estimate of 0.70 percent for the first component. This suggests that the variation in the two samples of RABBITS that are not accounted for by controlling for Tow and NBVEH remains sizable.

The overall effectiveness of the automatic restraint system in reducing serious and fatal injuries is estimated to be 18.78 percent. The effectiveness of the automatic restraint system attributed to an increase in restraint usage is estimated to be 13.9%, which is statistically significant at $\alpha = 0.10$.

The Effect of Deleting Cases with Missing Restraint Usage Information

Table 4.30 shows that about 10% of the cases have unknown restraint usage information. The effect of the deletion of these cases is examined below.

First, Table 4.30 shows that the proportion of cases with missing restraint usage information is not significantly different between the two types of restraint systems.

Table 4.30

Availability of RABBIT TYPE × Restraint Usage information (Colorado)

Rabbit Type	Known Restraint Usage	Unknown Restraint Usage	Total
Manual	1394 (89.70%)	160 (10.30%)	1554 [74.89%]
Automatic	462 (88.60%)	59 (11.32%)	521 [25.11%]
Total	1856 (89.45%)	219 (10.55)	2075

$\chi^2 = 0.4$, d.f. = 1, $p = 0.51$

Next, Table 4.26 compares the Pearson Chi-square statistics based on the total population to the Pearson Chi-square statistics based on the subpopulation with known restraint usage information. Their deletion again does not tend to distort the underlying relationships between these variables and RABBIT TYPE and also INJAK.

Finally, Table 4.31 compares the (A+K)-injury rates between the manual and the automatic restraint systems based on the total population, and Table 4.32 provides an analogous comparison based on the subpopulation with known restraint usage information. These two tables together show that by deleting these cases

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Table 4.31

(RABBIT TYPE × INJAK) based on total population
Colorado

Total Population	INJAK 0	INJAK 1	Total
Manual	1326 (93.51%)	123 (8.49%)	1449 [75.31%]
Automatic	441 (92.84%)	34 (7.16%)	475 [24.69%]
Total	1767 (91.84%)	157 (8.16%)	1924 *

*151 unknown INJAK cases

Table 4.32

(RABBIT TYPE × INJAK) based on subpopulation
with known restraint usage information
(Colorado)

Known Restraint Usage	INJAK 0	INJAK 1	Total
Manual	1199 (92.02%)	104 (7.98%)	1303 [75.54%]
Automatic	390 (92.42%)	32 (7.58%)	422 [24.46%]
Total	1589 (92.12%)	136 (7.88%)	1725

with unknown restraint usage information, the injury rate for occupants of manual restraint systems decreases from 8.49 percent to 7.98 percent, while the injury rate for occupants of automatic restraint systems increases from 7.16 percent to 7.58 percent. This suggests that the subsequent effectiveness estimate will be on the conservative side because the deletion of these cases with unknown restraint usage information decreases the observed overall serious injury rate reduction from 1.33 (=8.49% - 7.16) percent to 0.40 (=7.98% - 7.58) percent.

With these observations, one can again reasonably conclude that the overall effect of the deletion of unknown belt usage cases will be minimal.

Analysis of ALABAMA Data

The primary reason limiting the usefulness of Alabama accident data is that occupant information such as age, sex, restraint usage, and injury severity is available only for the injured occupants. This results in the following problems.

1. Over 90 percent of the occupants are not injured, and hence have missing occupant information. Since one can ascertain the presence of a driver with additional driver information, one may reasonably assume that a driver with missing injury information is uninjured. On the other hand, one cannot ascertain the presence or absence of a right front occupant in each vehicle. Consequently, one must restrict attention to the subpopulation of drivers.

2. For the overwhelming majority of the cases, even when the driver is injured, the restraint usage information is missing. Thus, the statistical methodology applied to the preceding four states is not applicable here. Table 4.33 shows the extent to which the variable restraint usage is missing.

Table 4.33
(RABBIT TYPE × RESTRAINT USAGE) for driver only
(Alabama)

	Restraint Usage			
Rabbit Type	Belted	Unbelted	Unknown/ Not Stated	Total
Manual	1 (0.13%)	47 (6.12%)	720 (93.75%)	768 [79.09%]
Automatic	3 (1.48%)	5 (2.46%)	195 (96.06%)	203 [20.91%]
Total	4 (0.41%)	52 (5.36%)	915 (94.23%)	971

For the following, if a driver's injury information is missing, he is assumed to be uninjured and hence INJAK is defined as follows:

$$\text{INJAK} = \begin{cases} 0 \text{ if injury} = \text{B, C, or not stated} \\ 1 \text{ if injury} = \text{A or K} \end{cases}$$

Table 4.34 contrasts the driver (A+K)-injury distribution of manual restraint systems to that of the automatic restraint system. The observed

Table 4.34
(RABBIT TYPE × INJAK) for drivers only
(Alabama)

Rabbit Type	INJAK Uninjured	INJAK Injured	Total
Manual	679 (92.76%)	53 (7.24%)	732 [78.79%]
Automatic	193 (97.97%)	4 (2.03%)	197 [21.21%]
Total	872 (93.9%)	57 (6.1%)	929*

*42 cases with missing injury information.

injury rate reduction is 5.21 percent which is somewhat higher than observed for the preceding four states although the quality of the belt usage data does raise some questions about Alabama's accident data.

Analysis of SOUTH CAROLINA Data

The same reason that limits the usefulness of the Alabama accident data also limits the usefulness of the South Carolina accident data. Table 4.35 illustrates the problem concerning missing restraint usage information. In fact, it appears that South Carolina and Alabama use very similar statewide accident report forms.

Table 4.36 compares the driver (A+K)-injury distribution for manual restraint systems to that of the automatic restraint systems. Here the observed injury rate reduction is 2.82 percent which is more in line with those observed for New York, North Carolina, Maryland, and Colorado.

Table 4.35

(RABBIT TYPE × RESTRAINT USAGE) for drivers only
(South Carolina)

Rabbit Type	Restraint Usage: Belted	Unbelted	Unknown/ Not Stated	Total
Manual	1 (0.53%)	13 (6.84%)	176 (92.63%)	190 [78.51%]
Automatic	1 (1.92%)	2 (3.85%)	49 (94.23%)	52 [21.07%]
Total	2 (0.83%)	15 (6.20%)	225 (92.98%)	242

Table 4.36
(RABBIT TYPE × INJAK) for drivers only
(South Carolina)

Rabbit Type	INJAK: Uninjured	Injured	Total
Manual	181 (92.26%)	9 (4.74%)	190 [78.51%]
Automatic	51 (98.08%)	1 (1.92%)	52 [21.49%]
Total	232 (95.87%)	10 (4.13%)	242

CHAPTER 5 SUMMARY AND DISCUSSION

Summary

This study attempts to examine the serious (A+K)-injury reducing potential of automatic shoulder belt/knee bolster restraint systems by comparing the (A+K)-injury experiences of the occupants of VW Rabbits equipped with the manual (or active) 3-point lap and shoulder belt restraint systems with the (A+K)-injury experiences of occupants of Rabbits equipped with the automatic (or passive) shoulder belt/knee bolster restraint systems.

Of primary interest is the net effect on the serious injury rates of front seat occupants of automatic belt Rabbits as compared to those in the conventional belt Rabbits. Of further interest is not only the usage rates in the two types of vehicles but also the relative contribution to the injury rate reduction attributable to belt usage versus belt system differences. Finally, of considerable interest is the adequacy of statewide accident data for carrying out studies such as this.

The study data consists of VW Rabbit accident data for the period 1975-1979 from New York, North Carolina, Maryland, Colorado, Alabama and South Carolina. As has been seen, the primary analyses are based on data from New York, North Carolina, Maryland and Colorado due to data limitations (quantity and quality) with Alabama and South Carolina.

No attempt has been made to combine data across states due to slightly different definitions of variables (e.g., definition of A-injury), differing reporting thresholds among the states, and occasionally differing distributions of the data among the states (e.g., the "drivable" variable). However, by using the (A+K)-injury criterion, there are reasonable sample sizes within each of the states (ranging from 1924 occupants in Colorado to 5046 in New York) and the police determination of A or K injuries should be quite reliable

Once the data files were set up, the analysis procedures were essentially the same for each state. First, since belt usage is such an important variable and it was missing in from 10 to 15 percent of the cases for the four primary states, an analysis was carried out to show that these missing belt usage cases occur essentially at random; i.e , that they do not introduce any serious biases in the data.

Secondly, in all accident data analyses there are certain variables that interact with the variables of interest -- here, RABBIT TYPE and INJAS (serious injury). As a result, to the extent allowable by the data, the confounding effect of these variables should be removed. This was done by identifying these variables (i.e., variable screening) and then smoothing the data using categorical data models (i.e., weighted least squares procedures via the GENCAT computer program).

Finally, as there is not only interest in the overall (A+K)-injury reduction but also the effect of various components such as usage rate differences and restraint system differences, the overall injury rate difference was expressed in terms of its components: usage rate differences, belt system effectiveness differences, and the residual referred to as sample variation. Estimates of these effects were then derived for New York, North Carolina, Maryland and Colorado using the GENCAT program.

Although the unknown belt usage rates are 15.5 percent, 9.5 percent, 13.0 percent and 10.5 percent for New York, North Carolina, Maryland and Colorado, respectively, analysis of these cases indicated no systematic biases that would invalidate the results. Indeed, the unknown belt cases appear to arise essentially randomly in each of the states with respect to the other variables of interest.

In each of the states, among the most important confounding variables to control for were restraint usage and number of vehicles involved (single vs. multi). This consistency increased the confidence in the screening procedure utilized.

Restraint usage rates by system type and state are presented in Table 5.1 along with effectiveness estimates. As mentioned in Chapter 2, although the usage rates differ considerably among the states, the ratio of the rates between belt systems (.506, .386, .564, .637 for NY, NC, MD, CO, respectively) remains reasonably constant with, as expected, a considerable increase in usage with the automatic restraint systems.

Overall (A+K)-injury rates by system type and state are given in Table 5.2 along with (A+K)-injury rate reduction effectiveness estimates.

Again, the serious injury rates differ among states due to a combination of the factors mentioned in Chapter 2 -- crash severity differences, reporting threshold differences, reporting errors, and definitional differences in A-injuries. Nonetheless the ratio (I_M/I_A) is quite constant across states

Table 5.1

Restraint usage rates by system type and state

State	Restraint Usage Rate Manual (s.e.) R_M	Automatic (s.e.) R_A	Ratio R_M/R_A
NY	28.96 (1.67)	57.25 (1.84)	0.506
NC	16.63 (1.10)	43.08 (2.66)	0.386
MD	41.60 (1.20)	73.70 (1.83)	0.564
CO	29.37 (2.24)	46.13 (3.97)	0 637

Table 5.2

Overall (A+K)-injury rates and effectiveness estimates by system type and state

State	Overall (A+K) Injury Rate Manual (s.e.) I_M	Automatic (s.e.) I_A	Ratio I_M/I_A	Effectiveness $\frac{I_M - I_A}{I_M} \times 100$ (s.e.)
NY	6.33 (0.41)	5.24 (0.72)	1.2	17.27 (12.30)
NC	5.21 (0.65)	3.83 (1.05)	1.4	26.38 (22.06)
MD	2.95 (0.41)	1.84 (0.56)	1.6	37.61 (20.79)
CO	5.07 (0.98)	4.12 (1.17)	1.2	18.78 (27.03)

(1.2, 1.4, 1.6, 1.2, respectively), suggesting that occupants of automatic belt Rabbits are 20-30 percent less likely to experience serious injuries in a crash.

Table 5.3 provides the estimates (s.e.) of the various components of the serious injury rate reduction; i.e., the components due to restraint usage rate differences, system differences, and sample variation (or residual). To the extent that the serious injury rates are significantly reduced (depending upon the α-level selected) for the automatic Rabbit, the consistent and significant component leading to this reduction is the increased belt usage level for the automatic Rabbit. It would seem that the two systems, when used, are equally effective in reducing serious injuries. It is also apparent from the estimates of sample variation that the most important factors have been accounted for in this analysis.

Table 5.3

Estimates of the components of the overall serious injury rate reduction

	Estimate (s.e.)	95% Confidence Interval	Percentage Relative to Overall (A+K)-Injury for Manual Rabbit (s.e.)
Overall (A+K)-Injury Rate Reduction (I_M-I_A)			
NY	1.09% (0.81%)	(-0.50%, 2.68%)	17.27% (12.30%)
NC	1.38% (1.23%)	(-1.17%, 3.63%)	26.38% (22.06%)
MD	1.11% (0.69%)	(-0.24%, 2.46%)	37.61% (20.79%)
CO	0.95% (1.47%)	(-0.97%, 2.87%)	18.78% (27.03%)
Component Attributed to Restraint Usage Rate Differences			
NY	1.22% (0.23%)*	(0.77%, 1.67%)	19.27% (3.34%)*
NC	0.85% (0.45%)**	(-0.02%, 1.72%)	16.33% (8.40%)**
MD	0.46% (0.26%)**	(-0.05%, 0.97%)	15.55% (8.66%)**
CO	0.70% (0.36%)**	(-0.01%, 1.41%)	13.87% (7.81%)**
Component Attributed to System Differences			
NY	-0.22% (0.56%)	(-1.32%, 0.88%)	-3.48% (8.85%)
NC	-0.35% (0.87%)	(-2.07%, 1.36%)	-6.81% (17.12%)
MD	0.74% (0.55%)	(-0.34%, 1.82%)	25.21% (17.61%)
CO	-0.57% (0.84%)	(-2.20%, 1.06%)	-11.31% (16.79%)
Component Attributed to Sample Variation (Residual)			
NY	0.09% (0.58%)	(-1.05%, 1.23%)	1.48% (7.92%)
NC	0.88% (0.90%)	(-0.89%, 2.64%)	16.87% (16.62%)
MD	-0.09% (0.44%)	(-0.96%, 0.77%)	-3.15% (14.88%)
CO	0.82% (1.30%)	(-1.73%, 2.65%)	16.22% (23.63%)

*Significant at $\alpha = 0.05$
**Significant at $\alpha = 0.10$

Thus, from this real-world accident data from New York, North Carolina, Maryland and Colorado, occupants in automatic belt Rabbits experienced some [illegible] to 30 percent fewer (A+K)-injuries than their counterparts in Rabbits with conventional 3-point belt systems. The overriding factor for this reduction was an increase (at least two-fold) in the belt usage rates in the automatic belt Rabbits.

Discussion

Not unexpectedly, there are a variety of pros and cons in using state accident data to address questions such as the serious injury reduction of automatic belt systems in VW Rabbits. In spite of many limitations and qualifications, it currently represents the only possible accident data base with which to even begin to answer the question. As will be seen, there are many reasons for not combining such data across states. Nevertheless, the analysis within multiple states with reasonable data quality does allow for a examination of the consistency of results between states and increases the confidence placed in the results of the analysis. Because of a variety of differences between states it is to be expected that there will be variability in the estimates derived. The extent and acceptability of this variation for the particular analysis being carried out should then define the answer to the question of the usefulness of state accident data in addressing the question. For the present study, it is felt that the analysis of New York, North Carolina, Maryland and Colorado data provide most useful and otherwise unavailable input into answering the questions posed.

The fact that the multi-state data base represents the <u>only</u> reasonable file available for analysis is clear. Outside data collected by the federal government, there is no other existing accident data to consider. And with respect to the former, candidate files derive from the following programs: FARS (Fatal Accident Reporting System), MDAI (Multi-Disciplinary Accident Investigation), RSEP (Restraint System Effectiveness Program), NCSS (National Crash Severity Study), and NASS (National Accident Sampling System).

FARS, a census of detailed information on motor vehicle fatalities in the United States, is seriously lacking in sample size (see Table 5.4 for fatality counts for the six states used in this study). Hedlund (1980) does use the FARS data for 1975-1979 to compare the fatality rates (F_A and F_M) per million

Table 5.4

Occupant fatalities* by Rabbit type and state

State	Belt Type	Fatality K (%)	Non-Fatally Injured + Uninjured $\bar{K}$	Total
New York	Manual	22 (0.55%)	3993	4015
	Automatic	6 (0.58%)	1025	1031
North Carolina	Manual	12 (0.76%)	1568	1580
	Automatic	1 (0.21%)	466	467
Maryland	Manual	3 (0.18%)	1946	1949
	Automatic	1 (0.17%)	639	640
Colorado	Manual	5 (0.35%)	1444	1449
	Automatic	4 (0.84%)	471	475
Alabama	Manual	2 (0.29%	730	732
	Automatic	0 (0.00%)	197	197
South Carolina	Manual	1 (0.53%)	189	190
	Automatic	0 (0.00%)	52	52

*Without regard to belt usage information.

vehicle months for the front seat occupants of automatic vs. manual Rabbits. He concludes that $F_M > F_A$ with a best estimate being

$$F = \frac{F_M}{F_A} = 1.2$$

or an effectiveness in fatality reduction of approximately 17 percent. He also concludes that there appear to be problems with the 1975-1977 FARS data and, with a total (all years) of but 69 fatalities in automatic Rabbits, recommends further investigation as additional data becomes available. Although the quality of the information is superior, the lack of cases seriously limits any analysis.

MDAI has for the past number of years focused on air bag-equipped car crashes and on school bus accidents. Thus, even if they were representative and sufficiently numerous, the target group is not appropriate for this study.

RSEP and NCSS, prototypes for NASS, lack data quantity (each around 10,000 accidents) and/or timeliness -- RSEP used only 1973-75 model cars. The ongoing

NASS program likewise is inadequate with respect to data quantity and, commencing in 1978, does not have accident data for as broad a period as is available through the network of state accident data.

Thus, if the questions of interest are to be investigated, it is possible only through examining state accident data. In the remainder of this chapter, many of the problems encountered in using this data are addressed. These include both interstate data problems as well as intrastate problems. Examples of the former include variations in

(i) Reporting thresholds
(ii) Definitions of the accident variables
(iii) Degree and nature of computerization
(iv) Quality including missing data rates, police reporting errors.

Examples of intrastate data problems include

(i) Periodic changes in the accident report forms during the study period

(ii) Variability in the quality of the data from item to item (e.g., restraint usage vs. driver age) with respect to missing data and police classification errors.

In comparing results across states, differences in reporting thresholds can yield apparently inconsistent data. For example, in New York State, police report only on injury-producing accidents -- motorists report property damage only accidents. Thus, any analysis based on police reports from New York will have disproportionately more serious injuries -- essentially by definition. Everything else being equal, this should lead to a somewhat lower estimate of the effectiveness of the automatic belt system (Campbell and Reinfurt, 1979). The generally higher serious injury rates (see Table 2.8) for New York are consistent with the higher reporting threshold, as is the generally lower overall effectiveness estimate (17.3%). These results, which are consistent with the hypothesis, suggest caution in combining New York data with that of any other state.

No two statewide accident report forms in the United States are identical. Thus a data element which is available in one state (say, location of injury) may not even be available in other states. And even if it were, coding level definitions often differ on such generally critical variables as injury (e.g., "A" injury), belt use (e.g., not used vs. unknown), vehicle damage severity (e.g., TAD severity vs. minor, moderate, severe), impact site (e.g., initial point of contact: front vs. right front, center front, left front), accident type (e.g., car-car vs. two vehicle), etc. Obviously such incompatabilities not only reduce opportunities for combining data but also make it more difficult to compare results between states. It is advantageous in this application that comparisons are carried out basically within each of the states.

As mentioned earlier, only New York State among the six states has information on location of injury. One of the questions to be addressed in this study was whether the knee bolster might induce injury to the knee or lower leg of occupants in the automatic Rabbits. Table 5.5 suggests two problems even with the New York State injury by location data. First, knee is not identified -- only upper vs. lower leg. Second, over 60 percent of the cases (automatic and manual) have missing injury location data. The most that can be said is that, if the missing cases occurred at random, the automatic Rabbit occupants did not have disproportionately more "knee" injuries as defined by lower leg and/or upper leg.

Clearly state accident data is wanting in the important area of injury information. Relatively few states have more detailed information than that provided by the KABCO scale. And even here there are some definitional ambiguities that accompany that scale as has been mentioned previously.

There is considerable variability between states in the information from the accident report form that is computerized. Of utmost importance to this study was the VIN (Vehicle Identification Number). In fact the six states were selected on the basis of having readily-available computerized VIN information. Properly recording the VIN by the investigating officer and then correctly entering it on computer is a difficult process. Previous experience with North Carolina VIN's indicates that approximately 15 percent of accident-involved passenger cars failed the VIN edit check for the R. L. Polk VINA, a VIN-decoding computer program. Perhaps a similar failure rate has occurred in the data processing involved in this study. Provided it is non-systematic, its main effect is to decrease sample size.

This study placed an additional requirement on the VIN information, namely that the production number, which was passed against the VW file to obtain system type, was valid. The results of this secondary screening are shown in Table 5.6. Excepting South Carolina the failure rates appear tolerable. Nevertheless, systematic biases could cause problems with the other five states.

Table 5.5

Rabbit type by injury location

Rabbit Frequency (Row%)	Injury Location Unknown	Head	Face	Eye	Neck	Chest	Back
Manual	2457	617 (39.60)	185 (11.87)	7 (0.45)	142 (9.11)	81 (5.20)	101 (6.48)
Automatic	680	103 (29.34)	47 (13.39)	1 (0.28)	39 (11.11)	36 (10.26)	25 (7.12)
Total	3137	720 (37.72)	232 (12.15)	8 (0.42)	181 (9.48)	117 (6.13)	126 (6.60)

Rabbit Frequency (Row%)	Injury Location Upper Arm	Lower Arm	Abdomen	Upper Leg	Lower Leg	Entire Body	Total
Manual	82 (5.26)	86 (5.52)	17 (1.09)	35 (2.25)	153 (9.82)	52 (3.34)	1558 [81.61]
Automatic	26 (7.41)	24 (6.84)	9 (2.56)	9 (2.56)	23 (6.55)	9 (2.56)	351 [18.39]
Total	108 (5.66)	110 (5.76)	26 (1.36)	44 (2.30)	176 (9.22)	61 (3.20)	1909

Table 5.6
Rabbit belt type distribution by state

State	Belt Type Manual	Automatic	Unknown	Total
New York	2821 (72.4)	722 (18.5)	355 (9.1)	3898
North Carolina	1180 (64.1)	347 (18.8)	314 (17.1)	1841
Maryland	1603 (64.8)	525 (21.2)	346 (14.0)	2474
Colorado	1434 (69.6)	491 (23.8)	136 (6.6)	2061
Alabama	768 (65.4)	203 (17.3)	204 (17.4)	1175
South Carolina	190 (36.0)	52 (9.9)	285 (54.1)	527

The most important aspect of the data is quality, as judged by rates of missing data for certain key variables and by consistency in the data. An example of the latter would be observed usage rate differences within a state yielding estimates of effectiveness in reducing serious injury that are within the range of expectation from previous research. Characteristics of the missing data for a number of key variables (e.g., restraint usage, injury severity, occupant age, sex and seating position, accident year, model year, number of vehicles involved) have been addressed in Chapter 2, both in terms of magnitude and in terms of differences between belt systems within states and also across states.

As it has been determined that the data should not be combined across states but rather that parallel analyses should be run in four of the six states (New York, North Carolina, Maryland, and Colorado), the most important question becomes similarity of missing data rates by belt systems within states. Here generally the data for most of the variables appears acceptable. Of primary concern is the belt usage variable which is such an integral portion of the analysis.

The unknown belt usage rates are 15.6 percent, 9.6 percent, 13.0 percent, 10.6 percent, 94.2 percent and 93.0 percent for New York, North Carolina, Maryland, Colorado, Alabama, and South Carolina, respectively. Clearly Alabama's and South Carolina's rates suggest that their data are not very useful. For the other four states, the main effect of missing belt usage data is to reduce the study file size. Analyses in Chapter 4 of the effect of the missing data on serious injury rates by belt system for each of the states suggest that the missing belt usage cases are distributed similarly across the other variables within each belt type, thus not biasing the estimates.

At the next level, how reliable is the belt usage data? Various studies (Chi, 1980b) have addressed the question of the degree and nature of belt usage misclassification errors in police data. A priori one would not expect automatic belt usage rates to vary from 43 percent to 74 percent. In fact, from population-at-risk studies carried out by Phillips and Goodman (1980), one might expect somewhat higher rates within a much narrower range. Likewise, a priori one would not expect a range of 16 percent to nearly 42 percent in the usage rates for manual (or conventional) belts. In fact, even accounting for the fact that VW Rabbits are foreign, subcompact passenger cars, one might expect generally lower rates again with a narrower between-state range. Are the observed rates consistent with other "known" facts about seat belt effectiveness?

One approach to investigating this question is suggested by Hedlund (1980). It assumes that the two systems are equally effective ($e_M = e_A = e$) in reducing serious injury, which seems reasonable from the analyses described in Chapter 4. Then, based on the observed belt usage rates (u_M, u_A), the method calculates the common effectiveness rate (given the systems are in use) for each of the states. This estimate is contrasted with the generally accepted range of 0.5 to 0.6 for reducing serious injuries.

More specifically, let

$$R = \frac{\text{(A+K)-injury rate for manual belts}}{\text{(A+K)-injury rate for automatic belts}}$$

$$= \frac{1 - \text{(proportion of serious injuries prevented by M)}}{1 - \text{(proportion of serious injuries prevented by A)}}$$

$$= \frac{1 - \text{effectiveness of M}}{1 - \text{effectiveness of A}}$$

$$= \frac{1 - \text{(effectiveness of M given the belt was used)(usage rate of M)}}{1 - \text{(effectiveness of A given the sysem was used)(usage rate of A)}}$$

$$= \frac{1 - e_M u_M}{1 - e_A u_A}$$

Assuming $e_M = e_A = e$, the common effectiveness estimate $\hat{e} = \frac{R-1}{Ru_A - u_M}$ is determined for each state using the observed u_M, u_A, and R from Tables 2 and 2.8, is presented in Table 5.7. The magnitudes of $\hat{e}$ raise some questions

Table 5.7

Examination of the consistency of the belt usage data

State	u_M	u_A	R	$\hat{e}$
New York	0.290	0.572	1.294	0.65
North Carolina	0.163	0.426	1.385	0.90
Maryland	0.416	0.739	1.672	0.82
Colorado	0.254	0.468	1.186	0.62

regarding the quality of the belt usage information and/or about the assumption that the belt systems are equally effective.

One additional problem leading to potentially inconsistent within-state accident data relates to changes in either the report form document or the reporting threshold during the study period. Although there were no reporting threshold changes from 1975 through 1979, there were changes in the report forms (e.g., North Carolina in 1979; Maryland in 1977). An example of a problem arising from such a change was the increase in the proportion of A-injuries in North Carolina in 1979. Although there was no change in definition, the description on the document differed as follows:

1975-1978: A-Incapacitating

1979: A-Incapacitating (Injury obviously serious enough to prevent carrying on normal activities for at least 24 hours; e.g., massive loss of blood, broken bone)

Other changes can and do lead to data incompatabilities and inconsistencies. For this data set, changes were relatively minor within states.

In summary, the usefulness of state accident data for analysis tasks such as was involved in this study has at least two sides. If one requires rather precise effectiveness estimates rather than good "ballpark" estimates, it is probably inadequate. Certainly if there is alternative data such as NASS, this would be preferable. Without considerable records improvement at all levels (form design, data collection and processing), existing data does not appear to be able to be combined across states.

On the other hand, given adequate within-state sample size, reasonably consistent estimates across a number of states combined with careful attention to the quality of the data used does give one confidence in results. This has also recently been shown in a study of utility vehicle accidents in North Carolina and in Maryland (Reinfurt, et al, 1981). Certainly for the investment made, it would seem that the results (in both cases) should be most useful

REFERENCES

Campbell, B. J. and Reinfurt, D. W. (1979). The degree of benefit of belts in reducing injury - An attempt to explain study discrepancies. SAE Technical Paper Series 790684, Warrendale, PA.

Chi, G. Y. H. (1980a). Statistical evaluation of the effectiveness of FMVSS 214: Side door strength. (Report No. 4254-676) Hartford, CT: The Center for the Environment and Man, Inc.

Chi, G. Y. H. (1980b). The effect of belt usage misclassification errors on seat belt effectiveness estimates. Chapel Hill, N.C.: University of North Carolina Highway Safety Research Center.

Freeman, J. L., Koch, G. G., Hunter, W. W., and Lacey, J. H. (1975). Shoulder harness usage in the population of drivers at risk in North Carolina. Chapel Hill, N.C.: University of North Carolina Highway Safety Research Center.

Goldmuntz, L. and Gates, H. P. Jr. (1977). Comparative effectiveness of occupant restraint systems. Washington, D.C.: Economics and Science Planning.

Griffin, L. I. (1979). Estimating the effectivenss of passive restraint systems. Washington, D.C.: General Accounting Office.

Grizzle, J. E., Starmer, C. F., and Koch, G. G. (1969). Analysis of categorical data by linear models. Biometrics 25, 489-504.

Hart, P. D. (1978). Public attitudes toward passive restraint systems. (DOT-HS-803570). Washington, D.C.: National Highway Traffic Safety Administration.

Hedlund, J. H. (1980). Personal communication relating to the VW Rabbit automatic restraint experience. Washington, D.C: National Highway Traffic Safety Administration.

Higgins, J. E. and Koch, G. G. (1977). Variable selection and generalized Chi-square analysis of categorical data applied to a large cross-sectional occupational health survey. International Statistical Review 45, 51-62.

Huelke, D. F., Sherman, H. W., Murphy, M. J., Kaplan, R. J., and Flora, J. D. (1979). Effectiveness of current and future restraint systems in fatal and serious injury automobile crashes. SAE Technical Paper Series 790323, Warrendale, PA.

Johannessen, H. G., Johannessen, G. F., and Pulley, C. H. (1979). Assessment of seat belt usage - Methods/results/recommendations. SAE Technical Paper Series 790682, Warrendale, PA.

Landis, J. R., Stanish, W. M., Freeman, J. L., and Koch, G. G. (1976). A computer program for the generalized Chi-square analysis of categorical data using weighted least squares. (Technical Report No. 8) Chapel Hill, NC: University of North Carolina Department of Biostatistics.

Landis, J. R., Cooper, M. M., Kennedy, T., and Koch, G. G. (1979). A computer program for testing average partial association in three-way contingency tables (PARCAT). Chapel Hill, NC: University of North Carolina Department of Biostatistics.

McDermott, F. T. and Hough, D. E. (1979). Reduction in road fatalities and injuries after legislation for compulsory wearing of seat belts: Experience in Victoria and the rest of Australia. British Journal of Surgery 66, 518-521.

National Highway Traffic Safety Administration (1978). Public attitudes toward passive restraint systems. (Summary report). Washington, D.C.: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (1979). Occupant protection program. (Progress Report No. 2). Washington, D.C.: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (1980). Summary report on occupant restraint usage programs. Washington, D.C.: National Highway Traffic Safety Administration.

Phillips, B. M. and Goodman, D. M. (1980). Automatic safety belt systems owner usage and attitudes in GM Chevettes and VW Rabbits. (PB-80 202815). Princeton, NJ: Opinion Research Corporation.

Phillips, N. S. (1973). Alternate passive occupant restraint development. (PB-73 222153). Dayton, OH: Beta Industries, Inc.

Reinfurt, D. W. et al. (In Press). A comparison of rollover tendencies of certain utility vehicle groups with other passenger-type vehicles. Chapel Hill, NC: University of North Carolina Highway Safety Research Center and Washington, D.C.: The Insurance Institute for Highway Safety.

Reinfurt, D. W., Silva, C. Z., and Seila, A. F. (1976). A statistical analysis of seat belt effectiveness in 1973-1975 model cars involved in towaway crashes. Chapel Hill, NC: University of North Carolina Highway Safety Research Center.

Rosenau, W. and Welkey, G. M. (1980). Field performance of Volkswagen automatic restraint system. Wolfsburg, Germany: Volkswagenwerk AG.

Schimkat, H., Weissner, R., and Schmidt, G. (1974). A comparison between Volkswagen automatic restraint and three-point manual belt on the basis of dummy and cadaver tests. Proceedings of the 18th. Stapp Car Crash Conference, 293-302.

Seiffert, V. W. (1979). Volkswagen passive occupant protection system. (Progress Report). SAE Techical Paper Series 790326, Warrendale, PA.

Seiffert, V W., Oehm, K., and Paitula, H. (1974). Description of the Volkswagen restraint automatic (VW-RA) used in a fleet test program SAE Technical Paper Series 740046, Warrendale, PA

States, J. D., Miller, S. R., and Seiffert, V. W. (1978) Volkswagen's passive seat belt/knee bolster restraint (VW-RA) - A preliminary field performance evaluation. SAE Technical Paper Series 780436, Warrendale, PA.

Strother, C. (1978). Small car driver inflatable restraint system evaluation. (DOT-HS-805052, DOT-HS-805053). Washington, D.C.: National Highway Traffic Safety Administration.

U. S. General Accounting Office (1979). Passive restraint for automobile occupants - A closer look. (NIIS PB-79 298320) Washington, D C.: Department of Commerce.

Ventre, P., Rullien, J. C., et al. (1975). An objective analysis of the protection offered by active and passive restraint systems. SAE Technical Paper Series 750393, Warrendale, PA.

Westefeld, A. and Benjamin, M. P. (1976). Passive vs. active safety belt systems in Volkswagen Rabbits: A comparison of owner use habits and attitudes. (DOT-HS-801958). Washington, D.C. National Highway Traffic Safety Administration.

APPENDIX

Accident Report forms from NEW YORK, NORTH CAROLINA
MARYLAND, COLORADO, ALABAMA, and SOUTH CAROLINA

alabama

ALABAMA UNIFORM TRAFFIC ACCIDENT REPORT

SHADED AREAS TO BE USED BY DATA PROCESSING ONLY   SHEET ___ OF ___ SHEETS

LOCATION & TIME

DATE | COUNTY CODE NUMBER | TIME AM PM | DAY OF WEEK M T W Th F S S 1 2 3 4 5 6 7

Total No. Vehicles | ACCIDENT INVOLVED (Circle One or More) 1 SINGLE MOTOR VEHICLE 2 OVERTURNED IN ROAD 3 RAN OFF ROAD 4 PEDESTRIAN 5 PEDALCYCLE 6 MOTORCYCLE 7 TWO OR MORE MOTOR VEHICLES 8 RAN OFF ROAD & OVERTURNED 9 OTHER ___ 0 FIXED OBJECT IN ROADWAY OR OUT OF ROADWAY

ON STREET ROAD OR HIGHWAY | AT INTERSECTION OF OR BETWEEN | AND | TYPE

STREET OR ROAD CODE | STREET OR ROAD CODE | FEET MILES N E S W OF ___

CITY OR TOWN | CONTROLLED ACCESS HWY LOCATION (Circle One) 1 MAIN ROAD 2 FRONTAGE RD 3 MAIN ROAD AT INTERCHANGE 4 ENTRANCE RAMP 5 EXIT RAMP | N E S W BOUND LANE

UNIT # 1

DRIVER

DRIVER'S FULL NAME | STREET OR R F D | CITY & STATE | ZIP | DATE OF BIRTH | SEX | RACE

DRIVER LICENSE NUMBER | STATE | TYPE 1 AUTO 2 REG TRUCK 3 MOTORCYCLE 4 OTHER TRUCK 5 LEARNER 6 NONE | LICENSE RESTRICTION(S) | Complied With YES NO

OCCUPATION | DRIVER'S TELEPHONE NO | DRIVER CONDITION (Circle One) 1 NO APPARENT DEFECTS 2 APPARENTLY ASLEEP 3 FATIGUED 4 ILL 5 UNKNOWN 6 PHYSICAL DEFECTS

DRIVER SOBRIETY DRINKING YES NO UNKNOWN DRUGS YES NO UNKNOWN | TYPE TEST GIVEN | TEST RESULTS POS NEG | REFUSED TEST YES NO | CONTRIBUTING CIRCUMSTANCE(S)

VEHICLE

YEAR | MAKE | BODY | V I N | INSPECTION CERTIFICATE 1 CURRENT 2 EXPIRED 3 NONE 4 UNKNOWN | LICENSE TAG NUMBER | STATE | YEAR

OWNER'S NAME | STREET OR R F D | CITY & STATE | ZIP | SPEED LIMIT MPH | ESTIMATED SPEED MPH

TYPE (Circle One) 01 AUTO 02 PEDALCYCLE 03 STA WAGON 04 PANEL PICKUP 05 TR TRACTOR 06 OTHER TRUCK 07 COMM BUS 08 SCHOOL BUS 09 OTHER BUS 10 M-CYCLE SAFETY EQUIP USED YES NO 11 FARM MACH 12 OTHER ___

SPECIAL USE (Circle One) 01 NONE 02 TAXI 03 MILITARY 04 AMBULANCE 05 FARM USE 06 POLICE 07 WRECKER 08 FIRE FIGHTING 09 DRIVER TRAINING 10 GOV T 11 OTHER ___

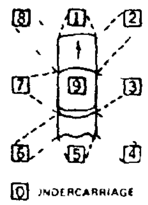
ATTACHMENT (Circle One) 1 NONE 2 MOBILE HOME 3 SEMI TRAILER 4 UTILITY TRAILER 5 FARM TRAILER 6 TRAILER WITH BOAT 7 CAMPER TRAILER 8 TOWED MOTOR VEH 9 PETROLEUM TANKER 0 OTHER ___

DEFECTS (Circle One or More) 1 NONE 2 BRAKES 3 LIGHTS 4 HORN 5 STEERING 6 WIPERS 7 TURN SIGNALS 8 TIRES 9 NOT KNOWN 0 OTHER | DEFECT CODES Contributed To Acc

DAMAGE SEVERITY 1 SLIGHT 2 MODERATE 3 SEVERE | AREA(S) DAMAGED (Use Codes) | APPROXIMATE COST TO REPAIR $ ___ | VEHICLES TOWED AWAY YES NO

VEHICLE TOWED BY WHOM | TO WHERE | TOTAL OCCUPANTS THIS UNIT

CIRCLE POINT OF INITIAL IMPACT



☐ UNIT # 2 OR ☐ PEDESTRIAN

DRIVER

DRIVER OR PEDESTRIAN'S NAME | STREET OR R F D | CITY & STATE | ZIP | DATE OF BIRTH | SEX | RACE

DRIVER LICENSE NUMBER | STATE | TYPE 1 AUTO 2 REG TRUCK 3 MOTORCYCLE 4 OTHER TRUCK 5 LEARNER 6 NONE | LICENSE RESTRICTION(S) | Complied With YES NO

OCCUPATION | DRIVER OR PED'S PHONE NO | DRIVER OR PED CONDITION (Circle One) 1 NO APPARENT DEFECTS 2 APPARENTLY ASLEEP 3 FATIGUED 4 ILL 5 UNKNOWN 6 PHYSICAL DEFECT

DRIVER OR PED SOBRIETY DRINKING YES NO UNKNOWN DRUGS YES NO UNKNOWN | TYPE TEST GIVEN | TEST RESULTS POS NEG | REFUSED TEST YES NO | CONTRIBUTING CIRCUMSTANCES

VEHICLE

YEAR | MAKE | BODY | V I N | INSPECTION CERTIFICATE 1 CURRENT 2 EXPIRED 3 NONE 4 UNKNOWN | LICENSE TAG NUMBER | STATE | YEAR

OWNER'S NAME | STREET OR R F D | CITY & STATE | ZIP | SPEED LIMIT MPH | ESTIMATED SPEED MPH

TYPE (Circle One) 01 AUTO 02 PEDALCYCLE 03 STA WAGON 04 PANEL PICKUP 05 TR TRACTOR 06 OTHER TRUCK 07 COMM BUS 08 SCHOOL BUS 09 OTHER BUS 10 M-CYCLE SAFETY EQUIP USED YES NO 11 FARM MACH 12 OTHER ___

SPECIAL USE (Circle One) 01 NONE 02 TAXI 03 MILITARY 04 AMBULANCE 05 FARM USE 06 POLICE 07 WRECKER 08 FIRE FIGHTING 09 DRIVER TRAINING 10 GOV T 11 OTHER ___

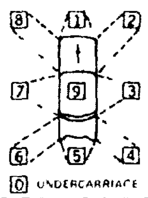
ATTACHMENT (Circle One) 1 NONE 2 MOBILE HOME 3 SEMI TRAILER 4 UTILITY TRAILER 5 FARM TRAILER 6 TRAILER WITH BOAT 7 CAMPER TRAILER 8 TOWED MOTOR VEH 9 PETROLEUM TANKER 0 OTHER ___

DEFECTS (Circle One or More) 1 NONE 2 BRAKES 3 LIGHTS 4 HORN 5 STEERING 6 WIPERS 7 TURN SIGNALS 8 TIRES 9 NOT KNOWN 0 OTHER | DEFECT CODES Contributed to Acc

DAMAGE SEVERITY 1 SLIGHT 2 MODERATE 3 SEVERE | AREA(S) DAMAGED (Use Codes) | APPROXIMATE COST TO REPAIR $ ___ | VEHICLES TOWED AWAY YES NO

VEHICLE TOWED BY WHOM | TO WHERE | TOTAL OCCUPANTS THIS UNIT

CIRCLE POINT OF INITIAL IMPACT



ACTIONS

DRIVER

(Circle One For Each Vehicle)

1	2		1	2		1	2		1	2	
01	01	Going Straight Ahead	05	05	Passing	09	09	Avoiding Animal or Vehicle	13	13	U Turn
02	02	Slowing or Stopping	06	06	Start From Parked	10	10	Turning Right	14	14	Merging
03	03	Start in Traffic Lane	07	07	Remain Parked Legally	11	11	Turning Left	15	15	Parking
04	04	Remain Stopped in Lane	08	08	Remain Parked Illegally	12	12	Backing			

PEDALCYCLE: 01 Riding With Traffic 02 Riding Against Traffic 03 Riding Across Street 04 Unknown

PEDESTRIAN

ROAD 1 DARK 2 LIGHT   CLOTHING 1 DARK 2 LIGHT   RETRO REFLECTIVE MATERIALS 1 CLOTHING 2 ITEMS 3 NONE

01	Crossing or Entering Intersection	04	Walking in Rdwy Against Traffic	07	Pushing or Working on Vehicle	10	Other in Roadway
02	Crossing or Entering Other	05	Standing in Roadway	08	Other Working in Rdwy	11	Not in Roadway
03	Walking in Rdwy with Traffic	06	Getting Off or On Vehicle	09	Playing in Roadway	12	OTHER ___

DAMAGE TO PROPERTY OTHER THAN VEHICLE (Name Object Show Ownership & Damage) | App. Cost of Repair $

WIT

WITNESS FULL NAME | ADDRESS | PHONE NO | AGE | SEX

WITNESS FULL NAME | ADDRESS | PHONE NO | AGE | SEX

AST FO 27 REVISED

Original size of document - 8 1/2 x 11

alabama

CODES

SEATING

1	2	3
4	5	6
7	8	9

M – Motorcycle
B Pedalcycle
O – Other
U Unknown
P Pedestrian

SEAT BELTS

LAP BELT ONLY
N None Installed
F – Fastened
U Unfastened
D Not Reported

LAP & SHOULDER BELT
E Not Used
G Lap Belt Only Used
M Both Belts Used
L Not Reported

EJECTED

Y Yes
P Partially
N – No
U Unknown

INJURY

K – Killed
A Visible signs of injury as bleeding wound or distorted member or had to be carried from scene
B Other visible injury as bruises abrasions swelling, limping, etc
C No visible injury but complaint of pain or momentary unconsciousness

FIRST AID BY

P – Police
A Amb Attend
D – Doctor
O – Other
U – Unknown
N – None

VICTIMS

	Age	Sex	Veh No	Seating	Seat Belts	Ejection	Injury	First Aid By
1 NAME ADDRESS / TAKEN TO TAKEN BY								
2 NAME ADDRESS / TAKEN TO TAKEN BY								

NARRATIVE & DIAGRAM

DIRECTION OF TRAVEL – VEHICLE 1 – N E S W VEHICLE 2 N E S W | MILES N E S W TO

INDICATE ROADWAY WIDTH ____ FEET

DESCRIBE WHAT HAPPENED (REFER TO VEHICLES BY NUMBER)

ROADWAY & ENVIRONMENT

LIGHT (Circle One)
1 DAYLIGHT
2 DAWN
3 DUSK
4 DARKNESS
5 DARKNESS RD LIGHTED

WEATHER (Circle One)
1 – CLEAR
2 – CLOUDY
3 RAINING
4 – FOG
5 – SNOWING SLEETING
6 HAILING

LOCALE (Circle One)
1 OPEN COUNTRY
2 RESIDENTIAL
3 SHOP'G OR BUSINESS
4 – MFG or INDUSTRIAL
5 – SCHOOL or PLAY D
6 OTHER

DEFECTS
1 2 (Circle One or More)
1 1 – SHOULDERS LOW
2 2 SHOULDERS HIGH
3 3 HOLES BUMPS ETC
4 4 – LOOSE MATERIAL ON SURFACES
5 5 – ROAD UNDER CONST
6 6 NONE
7 7 OTHER

CONSTRUCTION (Circle One For Each Vehicle)
1 2
1 1 – ASPHALT
2 2 – CONCRETE
3 3 BRICK
4 4 – DIRT
5 5 OTHER

CONDITION (Circle One For Each Veh)
1 2
1 1 – DRY
2 2 – WET
3 3 SNOWY ICY
4 4 MUDDY
5 5 – HAZARDOUS MATERIAL

VISION OBSCURED (Circle One For Each Veh.)
1 2
01 01 – NOT OBSCURED
02 02 – RAIN SNOW ICE, ETC. ON WINDSHIELD
03 03 – TREES CROPS BUSHES ETC
04 04 BUILDINGS
05 05 – EMBANKMENT
06 06 SIGNBOARD
07 07 – HILLCREST
08 08 – PARKED VEHICLE(S)
09 09 – MOVING VEHICLE(S)
10 10 – BLINDED BY HEADLIGHTS
11 11 – BLINDED BY SUNLIGHT
12 12 – OTHER
13 12 – UNKNOWN

CHARACTER
1 2 (Circle One For Each Veh)
1 1 Straight – Level
2 2 Straight Down Grade
3 3 Straight Up Grade
4 4 Straight Hillcrest
5 5 – Curve Level
6 6 Curve Down Grade
7 7 Curve Up Grade
8 8 Curve Hillcrest
Vehicles Traveling Same Rdwy
Yes No (Circle One)

TRAFFIC CONTROL
1 2 (Circle One For Each Vehicle)
1 1 – STOP SIGN
2 2 STOP & GO SIGNAL
3 3 YIELD SIGN
4 OFFICER OR FLAGMAN
5 5 RR CROSSING GATES
6 6 RR FLASHING LIGHTS
7 7 NONE
8 8 OTHER
Yes Yes / No No } FUNCTIONING

ROADWAY LANES
1 2 (Circle One For Each Vehicle)
1 1 – ONE LANE
2 2 – TWO LANES
3 3 – THREE LANES
4 4 FOUR LANES
5 5 – FIVE LANES
6 6 SIX LANES OR MORE
7 7 UNPAVED (Any Width)
8 8 ALLEY
Yes Yes / No No } ONE WAY STREET

ROADWAY DIVIDED BY
1 2 (Circle One For Each Vehicle)
MEDIAN CONSTRUCTION
1 1 – CONCRETE
2 2 – ROUGH SURFACE
3 3 EARTH
4 4 – PAINTED
MEDIAN BARRIER
1 1 – CONCRETE
2 2 – METAL GUARDRAIL
3 3 FENCE
4 4 – OTHER
Yes Yes / No No } MEDIAN

INVESTIGATION

SUMMONS NUMBER | NAME OF PERSON CHARGED | CONTRIBUTING CIRCUMSTANCE(S)

SUMMONS NUMBER | NAME OF PERSON CHARGED | CONTRIBUTING CIRCUMSTANCE(S)

POLICE AGENCY NOTIFIED · AM PM | POLICE ARRIVED · AM PM | AMBULANCE ARRIVED · AM PM | TRAFFIC FLOW RESTORED · AM PM | NAME OF PHOTOGRAPHER

NAME OF INVESTIGATING OFFICER | BADGE NUMBER | POLICE AGENCY

NAME OF OTHER OFFICERS AT SCENE | BADGE NUMBER S | POLICE AGENCY

THE DATA ON THIS REPORT REFLECTS MY BEST KNOWLEDGE OPINION AND BELIEF COVERING THE ACCIDENT BUT NO WARRANT IS MADE AS TO THE FACTUAL ACCURACY THEREOF

SIGNATURE OF INVESTIGATING OFFICER | DATE

CONTRIBUTING CIRCUMSTANCE(S)

10 – No Improper Driving
11 – Violations Unknown
12 Imp. Backing
13 Changing Lanes Imp.
14 Parking Improperly
15 – Failure to Dim Lights
16 Lights Improper
17 – Veh. Unsafe Cond
18 – Driving in Wrong Lane
19 No Sig. Imp. Sig.
20 Following Too Closely
21 – Defective Brakes
22 Exceeding Speed Limit
23 Exceeding Safe Speed
24 Disregard Sign Sig.
25 No Right of Way
26 Wrong Side of Road
27 – Passing On Hill
28 Passing on Curve
29 – Other Improper Passing
30 – Turning Unlawfully
31 Driving in Safety Zone
32 Pass Stpd. School Bus
33 – Inattention
34 Other Moving Viol
35 Exc. Wt Ht LL Wh
36 Pedestrian Drunk
37 – Faulty Equipment
38 Walking Violation
39 – Min. Speed Law
40 Racing On Hwy
41 Drv under inf

Original size of document – 8 1/2 x 11

colorado

Mail To
DEPT OF REVENUE
Accident Records
4201 E Arkansas Ave
DENVER COLO 80222
SHEET ___ OF ___ SHEETS

STATE OF COLORADO INVESTIGATOR'S TRAFFIC ACCIDENT REPORT

ROAD CODE | MILE POST CODE | DR 447 7/72 | SERIAL NUMBER

SUMMARY

NON INJURY | INCOMPLETE REPORT | PRIVATE PROPERTY ACCIDENT | HIT AND RUN | DUI | BUS | CAB NO | CITY LOCATION CODE | DATE OF REPORT MO DAY YR

TOTAL VEHICLES | PERSONS INJURED | PERSONS KILLED | POLE NUMBER | ACCIDENT TYPE | PUBLIC PROPERTY OR EMPLOYEES INVOLVED | DISTRICT NUMBER

LOCATION

DATE OF ACCIDENT MO DAY YEAR | DAY OF WEEK | HOUR | AM | PM | CITY | COUNTY

HIGHWAY NUMBER US COLO INTERSTATE | STREET OR ROAD | AT INTERSECTION WITH OR NEAREST INTERSECTING

NON INTERSECTION | REFERENCE POINT No 1 | DISTANCE MI FT | OF | REFERENCE POINT No 2 | DISTANCE MI FT | OF

VEHICLE NO 1

DRIVER'S NAME FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP | HOME PHONE

DATE OF BIRTH | SEX | DRIVER LIC NO | STATE | TYPE | EXP DATE | MILITARY ☐ OR BUSINESS ADDRESS | BUS PHONE

YRS DRIVEN | DRIVER ED YES ☐ NO ☐ | DRIVER VIOLATIONS | VIOLATION CODE(S) | SUMMONS NO | COMMON CODES | VEHICLE TOWED BY

VEHICLE MAKE | YEAR | MODEL | BODY TYPE | COLOR | LICENSE PLATE NO | STATE | IDENTIFICATION NO

VEHICLE OWNER FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP

OWNER OF OTHER DAMAGED PROPERTY FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP

VEH NO 2 OR PED ☐ OR ☐

DRIVER'S NAME FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP | HOME PHONE

DATE OF BIRTH | SEX | DRIVER LIC NO | STATE | TYPE | EXP DATE | MILITARY ☐ OR BUSINESS ADDRESS | BUS PHONE

YRS DRIVEN | DRIVER ED YES ☐ NO ☐ | DRIVER VIOLATION(S) | VIOLATION CODE(S) | SUMMONS NO | COMMON CODES | VEHICLE TOWED BY

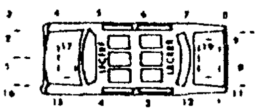
VEHICLE MAKE | YEAR | MODEL | BODY TYPE | COLOR | LICENSE PLATE NO | STATE | IDENTIFICATION NO

VEHICLE OWNER FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP

OWNER OF OTHER DAMAGED PROPERTY FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP

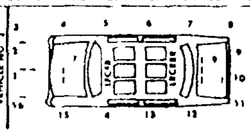
VEHICLE DAMAGE SEVERITY (Enter Codes in Vehicle Damage Area) SEVERITY CODES 1 SLIGHT OR MINOR 2 MODERATE 3 SEVERE OR EXTREME

VEHICLE NO 1



16 ___
20 Under ___

VEHICLE NO 2



16 ___
20 Under ___

Occupant Injury Severity (Enter codes for each occupant by seat position) Codes A—Fatal B Carried from scene C Minor visible injuries D Pain but no visible injuries E—No injury 1 Unknown

INJ PASSENGERS

INJURED'S NAME FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP | DATE OF BIRTH

SEX | VEH NO | POS IN VEH | TAKEN TO | TAKEN BY

INJURED'S NAME FIRST MIDDLE LAST | ADDRESS CITY STATE ZIP | DATE OF BIRTH

SEX | VEH NO | POS IN VEH | TAKEN TO | TAKEN BY

WEATHER COND | ROAD CONDITION | TRAFFIC CONTROL | STREET WIDTH | POINT OF IMPACT

DESCRIBE ACCIDENT

INVESTIGATION

NOTIFIED OF ACCIDENT MO DAY YR | HOUR | AM | PM | ARRIVAL AT SCENE MO DAY YR | HOUR | AM | PM | PHOTO TAKEN | YES | NO | INDICATE NORTH BY ARROW

OFFICER NUMBER | SIGNATURE | DETAIL | REVIEWING OFFICER

OFFICER NUMBER | SIGNATURE | DETAIL | LAW ENFORCEMENT AGENCY | CODE

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A TYPE OF ACCIDENT

RAN OFF ROAD NON COLLISION
- Right Side
- Left Side
- T intersection or end of road

NON COLLISION ON ROAD
- Overturned on road
- Other non-collision on road

COLLISION ON ROAD

Motor Vehicle
- Broadside
- Head on
- Rear end
- Sideswipe—same direction
- Sideswipe—opposite direction
- Approach turn
- Overtaking turn

Fixed Objects
- Utility pole
- Light pole
- Bridge rail
- Bridge abutment
- Under crossing column or pier
- Sign
- Traffic signal pole
- Culvert or headwall
- Embankment ditch
- Curb
- Guard rail
- Guard post
- Median barrier
- Fence
- Tree
- Large boulder (not in roadway)
- Barricade

Type of Fixed Objects (if applicable)
- Breakaway
- Non breakaway

Location of Fixed Objects (if applicable)
- On right of way
- In median
- Edge of travelled way

OTHER COLLISION
- Railroad train
- Parked motor vehicle
- Bicycle
- Rocks on roadway
- Machinery
- Fall from motor vehicle
- Other objects

Pedestrian
- School age to/from school
- All others

Animal
- Domestic
- Wild

FOR DIVIDED HWYS ONLY
- Stopped on median
- Entered opposing lanes
- Crossed opposing lanes

THIS SIDE OF REPORT IS CONFIDENTIAL

COMPLETE EACH SECTION

B ROAD CHARACTERISTICS—LANES

THRU LANES
- One
- Two
- Three
- Four
- Five
- Six
- Eight
- Other

SPECIAL LANES
- Left turn
- Right turn
- Acceleration
- Climb

DIVISION
- Island
- Curbed median
- Depressed median
- Painted median
- No divided

TRAFFIC FLOW
- One way
- Two way

C—LOCALITY
- Apartments stores factories
- One family homes
- Farms fields
- No marginal development
- Open country
- Rolling plains
- Mountains

D ROAD CHARACTERISTICS—SURFACE

SURFACE TYPE
- Concrete
- Blacktop
- Gravel
- Earth
- Other
- Unknown

SURFACE CONDITION
- Dry
- Wet
- Muddy
- Snowy
- Icy
- Slushy
- Icy road treatment

ADVERSE CONDITIONS
- None
- Foreign material on surface
- Obstruction not lighted dark
- Obstruction not lighted day
- Road under construction or repair
- Other

E ROAD DESCRIPTION AT ACCIDENT LOCATION

ROAD ELEMENTS

Intersection
- 3 way
- 4 way
- Other
- Non intersection
- Alley
- Driveway
- Construction detour
- R R grade crossing approach
- Bridge or viaduct
- Lane transition
- Off ramp
- On ramp
- Gore

ROAD DESCRIPTION
- Straight
- Curve
- Level
- On grade
- Hill crest

LIGHT CONDITION
- Daylight
- Dawn or dusk
- Dark no street light
- Dark street light

DEGREE OF ARTIFICIAL LIGHT
- Intermittent lighting
- Continuous lighting

F—ADVERSE WEATHER CONDITIONS
- None
- Rain
- Snow or sleet
- Fog
- Dust
- Wind

G—TRAFFIC CONTROL

1 2
- No control
- Officer flagman etc

SIGNALS
- Stop-go signal
- Pedestrian signal
- School signal
- Flashing red signal
- Flashing yellow signal
- Flashing red beacon
- Flashing yellow beacon
- Railroad signal with gate
- Railroad signal without gate
- Turn arrow
- Lane direction signal

SIGNS
- Stop
- Yield
- Curve or turn sign
- Advisory speed plate
- Speed limit sign
- One Way
- School crossing
- R R Crossing ahead
- R R crossbuck
- Pavement width transition
- Turn restricted prohibited
- Parking restricted prohibited
- Right turn on red light prohibition

MARKINGS
- Center line marking
- Lane line(s) marking
- No passing zone marking
- Pavement edge marking
- Left turn lane marking
- Right turn lane marking
- Cross walk marking
- Climb lane marking
- Pavement word markings
- Other control

H—VEHICLE CHARACTERISTICS

TYPE

1 2
- Passenger car
- Car with freight trailer
- Vehicle with home trailer
- Pick up truck
- Pick up truck w camper
- Truck 1 container
- Truck tractor
- Truck tractor—semi trailer
- Bus school
- Bus not school
- Taxicab
- Self propelled mobile home
- Minicycle
- Bicycle
- Motorscooter or motorbike
- Farm equipment
- Other

SPECIAL VEHICLES (if applicable)
- Military vehicle
- Emergency vehicle
- Government vehicle

CRASH HELMET USED (if applicable)
- Yes
- No

EYE PROTECTION (if applicable)
- Yes
- No

TOW REQUIRED (due to damage, as a result)
- Yes
- No

DEFECTS
- No Apparent defects
- Brakes defective
- Tires defective
- Other defects

PARKING (legally parked (no overtime))
- Yes
- No

I VEHICLE MOVEMENT

1 2 3
- Going straight
- Turning left
- Turning right
- Backing
- Stopped in traffic
- Entering parked position
- Entering alley or driveway
- Leaving parked position
- Leaving alley or driveway
- Entering at angle
- Wrong way—divided Hwy
- Overtaking and passing
- Slowing or stopping
- Turning right on red light

J—VISION OBSCUREMENTS—EXTERNAL

1 2 3
- Vision obscured
- Vision not obscured

K GENERAL DIRECTION OF TRAVEL

1 2
- North
- South
- East
- West

L—IMPROPER DRIVER ACTIONS

1 2
- No improper driving
- Careless driving
- Exceeded safe speed for conditions
- Exceeded lawful speed limit
- Failed to yield R O W at open intersection
- Failed to yield R O W to pedestrian
- Drove left of center or on wrong side
- Other improper turn
- Changing lanes improperly
- Passing on hill and on curve
- Other improper passing
- Wrong side of road no passing
- Following too closely
- Drove while asleep
- Inattentive to driving
- Signal violation
- Disregarded Stop sign
- Other traffic signal violation
- Parked vehicle ...
- Improper vehicle ...
- Defective vehicle
- ...
- Spilled load or obstacle on road
- Hit and run
- Improper backing
- Other improper actions
- Failed to yield R O W at ...
- Failed to yield R O W at Yield sign

M—IMPROPER PEDESTRIAN ACTIONS

1 2 3
- Crossing against signal
- Crossing not in crosswalk
- Walking in roadway with traffic
- Standing in roadway
- Playing in roadway
- Other in roadway
- Other

N PEDESTRIAN ACTIONS

1 2
- Crossing ...
- Walking in roadway ...
- Going ...
- Pushing or working on vehicle
- Other working in roadway
- Not in roadway
- Other action

O—CONDITION OF DRIVER & PEDESTRIAN

1 2 3
- Under the influence
- Had been drinking
- Had not been drinking
- Unknown if drinking

BODY DEFECTS OR CONDITIONS
- No apparent defects
- ... fatigued
- Apparently asleep
- Poor hearing or vision
- Other (explain on back)

P—SPEED DATA

	Speed mph	Estimated speed
Veh No 1		
Veh No 2		
Veh No 3		

Q VEHICLE 1

Odometer reading

Approx vehicle damage $

Approx damage caused to Veh 2 or other property $

SEAT BELT AND INJURY DATA Y Yes N No

		LF	CF	RF	LR	CR	RR
Lap Belt	Installed						
	Used						
Shoulder Harness	Installed						
	Used						
Occupant ejected							
Injury severity							

R VEHICLE 2

Odometer reading

Approx vehicle damage $

Approx damage caused by Veh 2 to other property $

SEAT BELT AND INJURY DATA Y Yes N No

		LF	CF	RF	LR	CR	RR
Lap Belt	Installed						
	Used						
Shoulder Harness	Installed						
	Used						
Occupant ejected							
Injury severity							

S—VEHICLE 3

Odometer reading

Approx vehicle damage $

Approx damage caused by Veh 3 to other property $

SEAT BELT AND INJURY DATA Y Yes N No

		LF	CF	RF	LR	CR	RR
Lap Belt	Installed						
	Used						
Shoulder Harness	Installed						
	Used						
Occupant ejected							
Injury severity							

B ... An important ... information Marked

O

R

Box Y

B No

Box No

DO NOT USE THIS BOX

Time Miscellaneous

Engr O

Pain ...

Highway System
- State Fwy
- State Hwy
- Fu... ...
- Foreign Road
- Rural
- Urban

Original size of document — 8 1/2 x 14

A 1 REPORT NO

2122350

STATE OF MARYLAND

MOTOR VEHICLE ACCIDENT REPORT

2 FORM ___ OF ___

3 LOCAL AREA CASE NO | 4 ACCIDENT DATE MO DAY YR | 5 TIME (MILITARY) | 6 DAY OF WEEK | 7 REPORT TYPE 1 TRAFFIC ACCIDENT 2 NON TRAFFIC ACCIDENT | 8 COUNTY | 9 TIME NOTIFIED (MILITARY) | 10 TIME ARRIVED (MILITARY)

11 ACCIDENT SEVERITY

12 FIRST HARMFUL EVENT
01 Other Motor Vehicle in transport 02 Parked Motor Vehicle 03 Motor Veh on other roadway 04 Pedestrian 05 Pedalcycle 06 Other Conveyance 07 Animal 08 Fixed Object 10 Other Object 11 Overturned 12 Other Non-Collision

13 SUBSEQUENT EVENTS

14 FIXED OBJECT STRUCK
01 Bridge/Overpass 02 Building 03 Culvert/Ditch 04 Curb Wall 05 Guardrail/Barrier 06 Embankment 07 Fence 08 Light support pole 09 Sign support pole 10 Other pole 11 Tree Shrubbery 12 Construction Barrier 13 Crash Attenuator 14 Other

15 COLLISION TYPE
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 OTHER 17 SINGLE VEH

16 RELATIONSHIP TO INTERSECTION

17 KIND OF LOCALITY
1 Manufacturing or Industrial 2 Shopping or Business 3 Residential 4 School or Recreational 5 Open Country

B 1 DAMAGE TO PROPERTY OTHER THAN VEHICLE OBJECT | 2 OWNER NAME | 3 DAMAGE SEVERITY 1 No Damage 2 Superficial 3 Moderate 4 Destroyed

C 1 ACCIDENT OCCURRED ON ROAD NAME | 3 DISTANCE 1 Feet 2 Miles | 5 REFERENCED ROAD NAME | 7 CITY ACCIDENT OCCURRED IN OR INDICATE RURAL | 8 MUNICIPAL CODE

2 TYPE ROUTE NO SUFFIX | 4 GOING FROM ACCIDENT 1 North 2 South 3 East 4 West 5 N/A | 6 TYPE ROUTE NO SUFFIX | 9 LOG MILE REFERENCE ON C1 AT C5 | 10 RAMP MOVEMENT 0 N/A 1 N→W 2 W→N 3 E→N 4 N→E 5 S→E 6 E→S 7 W→S 8 S→W 9 Other

D MOVEMENT OF VEHICLES
VEH 1 / VEH 2
01 Moving Constant Speed 02 Accelerating 03 Slowing or Stopping 04 Starting from Traffic Lane 05 Starting from Parked Pos 06 Stopped in Traffic Lane 07 Changing Lanes 08 Passing 09 Parking 10 Parked 11 Backing 12 Making Left Turn 13 Making Right Turn 14 Making Right Turn on Red 15 Making U Turn 16 Skidding 17 Driverless Moving Vehicle 18 Other/Unknown

DIRECTION PRIOR TO TURNING VEH 1 / VEH 2 — 1 N 2 S 3 E 4 W 5 N/A

E 1 ACCIDENT OCCURRED IN
01 Lane 1 02 Lane 2 03 Lane 3 04 Lane 4 05 Merge/Transition Lane 06 Acceleration Lane 07 Deceleration Lane 08 Left Turn Lane 09 Right Turn Lane 10 Left Shoulder 11 Right Shoulder 12 Center Median 13 Left Roadside 14 Right Roadside 15 Outside Trafficway 16 Median Crossover 17 Gore 18 Parking Lot 19 Other

F TRAFFIC CONTROLS
1 FUNCTIONING 2 NOT FUNCTIONING
01 Police Officer 02 RR Watchman Gate Etc 03 Stop & Go Signal 04 Flashing Signal 05 Lane Markings 06 Channelization Painted 07 Channelization Physical 08 Construction/Maintenance Controls 09 Warning Sign 10 Stop Sign 11 Yield Sign 12 Center Line 13 Edge Line 14 Other Traffic Control 15 No Control Present

G 1 MV UNIT NO | 2 HIT & RUN 1 NO 2 YES | 3 DRIVER NAME FIRST MIDDLE & LAST | 4 ADDRESS NO STREET CITY STATE & ZIP | 5 PHONE NO

6 DATE OF BIRTH MO DAY YR | 7 SEX | 8 DRIVER LICENSE NO | 9 CLASS | 10 RESTRICTIONS | 11 STATE | 12 YEARS DRV EXP | 13 DRIVER EDUCATION 1 Public 2 Comml 3 None 4 Unkn | 14 INJ SEV | 15 SAFETY EQPT | 16 EJT

8 / 1 2 3 / 4 5 6 / 7 / 8

OC NO	18 ST POS	19 AGE	20 SEX	21 INJ SEVERITY	22 SFTY EQPT	23 EJT	24 OCCUPANT NAME & ADDRESS
1							
2							
3							
4							

25 OWNER NAME & ADDRESS

26 MAKE | 27 MODEL | 28 YR | 29 VEHICLE ID NO | 30 PLATE NO | 31 STATE | 32 YR | 33 VEH TYPE | 34 TOWED TYPE | 35 DAMAGE SEVERITY 1 Disabling 2 Functional 3 Other Veh Damage 4 No Damage 5 Unknown

36 VEHICLE REMOVED BY | 37 VEHICLE REMOVED TO | 38 REMOVAL AUTHORITY 1 Owner 2 Driver 3 Officer 4 Occupant 5 Other 6 N/A

G 1 MV UNIT NO | 2 HIT & RUN 1 NO 2 YES | 3 DRIVER NAME FIRST MIDDLE & LAST | 4 ADDRESS NO STREET CITY STATE & ZIP | 5 PHONE NO

5 DATE OF BIRTH MO DAY YR | 7 SEX | 8 DRIVER LICENSE NO | 9 CLASS | 10 RESTRICTIONS | 11 STATE | 12 YEARS DRV EXP | 13 DRIVER EDUCATION 1 Public 2 Comml 3 None 4 Unkn | 14 INJ SEV | 15 SAFETY EQPT | 16 EJT

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1							
2							
3							
4							

25 OWNER NAME & ADDRESS

26 MAKE | 27 MODEL | 28 YR | 29 VEHICLE ID NO | 30 PLATE NO | 31 STATE | 32 YR | 33 VEH TYPE | 34 TOWED TYPE | 35 DAMAGE SEVERITY 1 Disabling 2 Functional 3 Other Veh Damage 4 No Damage 5 Unknown

36 VEHICLE REMOVED BY | 37 VEHICLE REMOVED TO | 38 REMOVAL AUTHORITY 1 Owner 2 Driver 3 Officer 4 Occupant 5 Other 6 N/A

REMOVE THIS STUB (& ATTACHED CARBON PAPERS) BEFORE COMPLETING REVERSE SIDE

INJURY SEVERITY
1 No Injury 2 Possible Injury 3 Non Incapacitating 4 Incapacitating 5 Fatal

SAFETY EQUIPMENT
01 Lap Belt 02 Harness Only 03 Belt & Harness 04 Child Restraint 05 Air Bag or other Passive Restraint 06 Helmet only 07 Eye protection only 08 Helmet & Eye protection 09 Other 10 None used 11 None available 12 Usage unknown

EJECTED
1 Not Ejected 2 Fully Ejected 3 Partially Ejected 4 Trapped 5 Unknown

maryland

Original size of document – 8½ x 11⅞

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FRONT 1 2 3 4 5 6 7 8 9 REAR

H-1 POINT OF IMPACT — VEH 1, VEH 2 — 10 Undercarriage, 14 Other, 15 None/Unknown

AREAS DAMAGED — VEH 1, VEH 2 — 11 Overturned, 12 Totaled, 13 Fire Damage — AREA DAMAGE ONLY

VEHICLE CONDITION — VEH 1, VEH 2
01 No Apparent Defects
02 Defective Brakes
03 Defective Headlights
04 Defective Rear Lights
05 Defective Steering
06 Puncture/Blowout
07 Tire Bare/Worn
08 Defective/Altered Fuel
09 Defective/Altered Suspension
10 Motorcycle Lights on Daylight
11 Other
12 Unknown

DRIVER CONDITION — VEH 1, VEH 2
1 Apparently Normal
2 Had been Drinking
3 Using Drugs
4 Physical Defects/Handicaps
5 Ill
6 Fatigued
7 Apparently Asleep
8 Blinded by Glare
9 Condition Unknown

I-1 ILLUMINATION — 1 Daylight, 2 Dawn, 3 Dusk, 4 Dark (Street lights on), 5 Dark (Street lights off), 6 Dark (No lights), 7 Unknown

2 WEATHER — 1 Clear, 2 Cloudy, 3 Foggy, 4 Raining, 5 Snowing, 6 Severe Winds, 7 Other, 8 Unknown

3 SURFACE TYPE — 1 Concrete, 2 Tar & Chip, 3 Asphalt/Blacktop, 4 Cobble, 5 Brick, 6 Dirt, 7 Other

4 ROADWAY SURFACE — 1 Wet, 2 Dry, 3 Snow, 4 Ice, 5 Mud, 6 Other, 7 Unknown

5 ROAD CONDITION — 1 No Defects, 2 Shoulder Defects, 3 Holes, Ruts, Etc., 4 Foreign Material, 5 Loose Surface Material, 6 Obstruction not Lighted, 7 Obstruction not Signaled, 8 View Obstructed, 9 Construction/Maintenance

6 ROAD CHARACTER — 1 Straight & Level, 2 Straight & Grade, 3 Straight & Hillcrest, 4 Curve & Level, 5 Curve & Grade, 6 Curve & Hillcrest, 7 On Bridge, 8 Other

7 SPEED LIMIT — 1 Unknown/NA, 2 25 MPH or Less, 3 30 MPH, 4 35 MPH, 5 40 MPH, 6 45 MPH, 7 50 MPH, 8 55 MPH

J-1 PED NO — 2 PED INDICATOR (1 Pedestrian, 2 Pedalcyclist) — 3 PED NAME — 4 PED BIRTHDATE

5 PED INJ SEV — 6 PED SEX — 7 ADDRESS-NO STREET CITY STATE & ZIP — 8 PHONE NO

9 PED MANEUVER
01 Cross/Enter Roadway at Intersection
02 Cross/Enter Roadway Not at Intersection
03 Walking/Riding on Road with Traffic
04 Walking/Riding on Road against Traffic
05 Playing
06 Standing
07 Getting on/off Veh
08 Pushing/Working on Veh
09 Other Working
10 Hitchhiking
11 Approaching/Leaving School Bus
12 Other
13 Unknown

10 PED CONDITION — 1 Apparently Normal, 2 Had been Drinking, 3 Using Drugs, 4 Physical Defects, 5 Other Handicaps, 6 Ill, 7 Fatigued, 8 Apparently Asleep, 9 Condition Unknown

11 PED VISIBILITY — 1 Light Clothing, 2 Dark Clothing, 3 Mixed Clothing, 4 Retro Reflective Material, 5 Head Light, 6 Rear Light/Reflector, 7 Head & Rear Lt/Reflector

PEDESTRIAN TRAFFIC CONTROLS — 12 FUNCTION NO — 13 NO FUNCTION NG — 1 Walk/Don't Walk Signal, 2 Push Button Control, 3 Crosswalk Marked, 4 Uniformed Crossing Guard, 5 Student Crossing Guard, 6 No Control Present, 7 N/A

14 PED LOCATION AT TIME OF ACCIDENT — 1 Shoulder, 2 Curb, 3 Sidewalk, 4 On Side of Way, 5 On Roadway at Crosswalk, 6 On Roadway, not a Crosswalk, 7 School Bus Zone, 8 Bikeway, 9 Unknown

15 BICYCLE MAKE WHEEL SIZE & OTHER DESCRIPTION

K-1 FIRST AID ADMINISTERED BY — 1 Policeman, 2 Fireman, 3 Ambulance Personnel, 4 Helicopter Personnel, 5 Refused, 6 Other, 7 None Adm, 8 Unknown — 2 EMS REPORT NO — 3 EMS REPORT NO — 4 INJURED TAKEN BY — 5 TO

L-1 UNIT — 2 CITATION NO — 3 CHARGE SEC SUB SEC PAR — 2 CITATION NO — 3 CHARGE SEC SUB SEC PAR — 2 CITATION NO — 3 CHARGE SEC SUB SEC PAR

M-1 PHOTO TAKEN (1 YES, 2 NO) — 2 INVEST'D AT SCENE (1 YES, 2 NO) — 3 INVEST'N COMPLETE (1 YES, 2 NO)

N ALCOHOL TEST — 1 VEH ONE — 2 VEH TWO — 3 PED — 1 Breathalyzer, 2 Blood, 3 Urine, 4 Post Mortem, 5 Refused, 6 None Offered

O TEST RESULTS — 1 VEH ONE — 2 VEH TWO — 3 PED

P-1 WITNESS NAME 1 — 2 ADDRESS — 3 PHONE NO
4 WITNESS NAME 2 — 5 ADDRESS — 6 PHONE NO

Q-1 DESCRIPTION

R-1 DIAGRAM — INDICATE NORTH BY ARROW →

R 2

S-1 ... PRIMARY ... — ... — 1 INVEST ... — 2 OFFICER ID NO — 3 AGENCY — 4 INSTALLATION

5 ... AREA — 6 ... — 7 SEC ... STUDY — 8 ... — 9 ID NO — 10 REVIEWER

VEHICLE TYPE
01 Motorcycle — 02 Automobile — 03 Station Wagon — 04 Limousine — 05 Light Duty Truck — 06 Heavy Duty Truck — 07 Truck/Road Tractor — 08 Recreation Vehicle — 09 Farm Vehicle — 10 Transit Bus — 11 Cross Country Bus — 12 School Bus — 13 Ambulance/Emergency — 14 Ambulance/Non Emer — 15 Fire Veh/Emergency — 16 Fire Veh/Non Emer — 17 Police Veh/Emer — 18 Police Veh/Non Emer — 19 Moped — 20 Comm Other Rig — 21 Tandem Trailer — 22 Mobile Home — 23 Travel Home/Trailer — 26 Other — 29 Unknown

TOWED VEHICLE ONLY

Original size of document — 8½ x 11¾

MV 104A (9/75) Cover Sheet – POLICE ACCIDENT REPORT (to be used with the MV 104A and MV 104AN)

Place this sheet over the front of the accident report so that the numbered arrows line up with the boxes of the same number along the edges of the report. This will explain the meaning of the numbers written in the boxes.

1 PEDESTRIAN LOCATION
1 Pedestrian at Intersection
2 Pedestrian Not at Intersection

2 PEDESTRIAN ACTION
1 Crossing With Signal
2 Crossing Against Signal
3 Crossing No Signal Marked Crosswalk
4 Crossing No Signal or Crosswalk
5 Walking Along Highway With Traffic
6 Walking Along Highway Against Traffic
7 Emerging from in Front of/Behind Parked Vehicle
8 Going To/From Stopped School Bus
9 Getting On/Off Vehicle Other Than School Bus
10 Pushing/Working On Car
11 Working in Roadway
12 Playing in Roadway
13 Other Actions in Roadway*
14 Not in Roadway (Indicate)*

3 TRAFFIC CONTROL
1 None
2 Traffic Signal
3 Stop Sign
4 Flashing Light
5 Yield Sign
6 Officer/Flagman/Guard
7 No Passing Zone
8 RR Crossing Sign
9 RR Crossing Flashing Lt
10 RR Crossing Gates
11 Stopped School Bus Red Lights Flashing
20 Other *

APPARENT CONTRIBUTING FACTORS

HUMAN
2 Alcohol Involvement
3 Backing Unsafely
4 Driver Inattention (Indicate)*
5 Driver Inexperience (Indicate)*
6 Drugs (Illegal)
7 Failure to Yield Right of Way
8 Fell Asleep
9 Following Too Closely
10 Illness
11 Lost Consciousness
12 Passenger Distraction
13 Passing or Lane Usage Improper
14 Pedestrian's Error/Confusion
15 Physical Disability
16 Prescription Medication
17 Traffic Control Disregarded
18 Turning Improperly
19 Unsafe Speed
40 Other Human *

VEHICULAR
41 Accelerator Defective
42 Brakes Defective
43 Headlights Defective
44 Other Lighting Defects
45 Oversized Vehicle
46 Steering Failure
47 Tire Failure/Inadequate
48 Tow Hitch Defective
49 Windshield Inadequate
60 Other Vehicular *

ENVIRONMENTAL
61 Animal's Action
62 Glare
63 Lane Marking Improper/Inadequate
64 Obstruction/Debris
65 Pavement Defective
66 Pavement Slippery
67 Shoulders Defective/Improper
68 Traffic Control Device Improper/Non-Working
69 View Obstructed/Limited
80 Other Environmental *

Vehicle 1 – 19
Vehicle 1 – 20
Vehicle 2 – 21
Vehicle 2 – 22

4 LIGHT CONDITIONS
1 Daylight
2 Dawn
3 Dusk
4 Dark Road Lighted
5 Dark Road Unlighted

State of New York
Department of Motor Vehicles
POLICE ACCIDENT REPORT
MV 104A (9/75)

* EXPLAIN IN ACCIDENT DESCRIPTION
IF A QUESTION DOES NOT APPLY, ENTER A DASH (—).
IF AN ANSWER IS UNKNOWN ENTER AN "X"

DIRECTION OF TRAVEL
N, E, S, W — 1 2 3 4 5 6 7 8
Vehicle 1 – 23
Vehicle 2 – 24

5 ROADWAY CHARACTER
1 Straight and Level
2 Straight and Grade
3 Straight at Hillcrest
4 Curve and Level
5 Curve and Grade
6 Curve at Hillcrest

6 ROADWAY SURFACE CONDITION
1 Dry
2 Wet
3 Muddy
4 Snow/Ice
5 Slush
10 Other*

7 WEATHER
1 Clear
2 Cloudy
3 Rain
4 Snow
5 Sleet/Hail/Freezing Rain
6 Fog/Smog/Smoke
10 Other*

LOCATION OF MOST SEVERE PHYSICAL COMPLAINT
1 Head
2 Face
3 Eye
4 Neck
5 Chest
6 Back
7 Shoulder Upper Arm
8 Elbow Lower Arm Hand
9 Abdomen - Pelvis
10 Hip Upper Leg
11 Knee Lower Leg-Foot
12 Entire Body

TYPE OF PHYSICAL COMPLAINT
1 Amputation
2 Concussion
3 Internal
4 Minor Bleeding
5 Severe Bleeding
6 Minor Burn
7 Moderate Burn
8 Severe Burn
9 Fracture - Dislocation
10 Contusion - Bruise
11 Abrasion
12 Complaint of Pain
13 None Visible

VICTIM'S PHYSICAL AND EMOTIONAL STATUS
1 Apparent Death
2 Unconscious
3 Semiconscious
4 Incoherent
5 Shock
6 Conscious

INJURED TAKEN
BY | TO

PRE ACCIDENT VEHICLE ACTION
1 Going Straight Ahead
2 Making Right Turn
3 Making Left Turn
4 Making U Turn
5 Starting from Parking
6 Starting in Traffic
7 Slowing or Stopping
8 Stopped in Traffic
9 Entering Parked Position
10 Parked
11 Avoiding Object in Roadway
12 Changing Lanes
13 Overtaking
14 Merging
15 Backing
20 Other*

Vehicle 1 – 25
Vehicle 2 – 26

LOCATION OF FIRST EVENT
1 On Roadway
2 Off Roadway
– 27

TYPE OF ACCIDENT
COLLISION WITH
1 Other Motor Vehicle
2 Pedestrian
3 Bicyclist
4 Animal
5 Railroad Train
10 Other Object (Not Fixed)*
COLLISION WITH FIXED OBJECT
11 Light Support/Utility Pole
12 Guide Rail
13 Crash Cushion
14 Sign Post
15 Tree
16 Building/Wall
17 Curbing
18 Fence
19 Bridge Structure
20 Culvert/Head Wall
21 Median/Barrier
22 Snow Embankment
23 Earth Embankment/Rock Cut/Ditch
24 Fire Hydrant
30 Other Fixed Object*
NON-COLLISION
31 Overturned
32 Fire/Explosion
33 Submersion
34 Ran Off Roadway Only
40 Other*

First Event – 28
SECOND EVENT
Vehicle 1 – 29
Vehicle 2 – 30

COVER SHEET

WHICH VEHICLE OCCUPIED
1 Vehicle No. 1
2 Vehicle No. 2
B Bicyclist
P Pedestrian
O Other*

POSITION IN/ON VEHICLE
1 Driver
2-7 Passengers
8 Riding/Hanging On Outside

SAFETY EQUIPMENT USED
1 No Restraint Used
2 Lap Belt
3 Harness
4 Lap Belt and Harness
5 Child Restraint
10 Other*

1 2 3 4 5 6 7 8

EJECTION FROM VEHICLE
1 Not Ejected
2 Partially Ejected
3 Ejected

AGE | SEX

8 9 10 11 12 13 14 15 16 17 18

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State of New York – Department of Motor Vehicles

POLICE ACCIDENT REPORT

DMV COPY

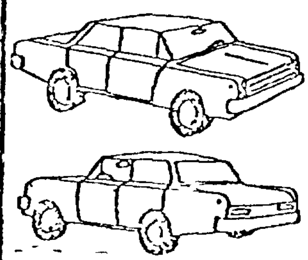
Page ___ of ___ Pages

Local Codes

VEHICLE 1

VEHICLE 2

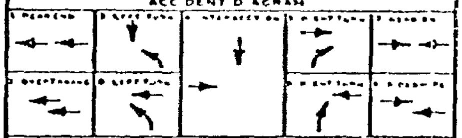
VEHICLE 1 DAMAGE



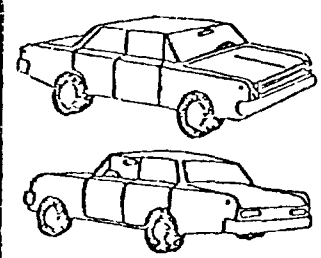
NO DAMAGE ☐ UNDERCARRIAGE ☐

VEHICLE BY
TOWED
TO

ACCIDENT DIAGRAM



VEHICLE 2 DAMAGE



NO DAMAGE ☐ UNDERCARRIAGE ☐

VEHICLE BY
TOWED
TO

new york

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In filling out these items on the back use the following examples

1 LOCALITY
1 Business
2 Residential
3 School & playground
4 Open country
2 SPEED LIMIT
3 ROAD FEATURE
1 Bridge or underpass
2 Driveway
3 Alley intersection
4 Intersection of two roadways
5 Non-intersection median crossover
6 End or beginning of divided highway
7 Other
4 ROAD SURFACE
1 Concrete
2 Smooth asphalt
3 Coarse asphalt
4 Gravel
5 Dirt or sand
6 Other

5 ROAD DEFECTS
1 Loose material on surface
2 Holes, deep ruts
3 Low shoulders
4 Soft shoulders
5 Other defects
6 Road under construction
7 No defects
6 ROAD CONDITION
1 Dry
2 Wet
3 Oily
4 Muddy
5 Snowy
6 Icy
7 LIGHT CONDITION
1 Daylight
2 Dusk
3 Dawn
4 Darkness (street lighted)
5 Darkness (street not lighted)

8 WEATHER
1 Clear
2 Cloudy
3 Raining
4 Snowing
5 Fog
6 Sleet or hail
9 TRAFFIC CONTROL
1 Stop sign
2 Yield sign
3 Stop and go signal
4 Flashing signal with stop sign
5 Flashing signal without stop sign
6 R R gate and flasher
7 R R flasher
8 Officer
9 Other device
10 No control present
10 OBJECT STRUCK (first only)
1 Tree
2 Utility pole
3 Fence or fence post
4 Guard rail or guardpost in median
5 Guardrail or guardpost on shoulder
6 Bridge
7 Underpass
8 Traffic island, curb or median
9 Sign or sign post
10 Animal
11 Ditch bank
12 Parked vehicle
13 Pedestrian
14 Other object
15 None
11 SOBRIETY
1 Had not been drinking
2 Drinking ability impaired
3 Drinking-unable to determine impairment
4 Unknown
12 PHYSICAL CONDITION
1 Ill
2 Fatigued
3 Asleep
4 Other physical impairment
5 Restriction not complied with
6 Normal
7 Condition not known
13 CHEMICAL TEST
14 PEDESTRIAN ACTION
1 Crossing at intersection
2 Crossing not at intersection
3 Coming from behind parked vehicle
4 Walking with traffic
5 Walking against traffic
6 Getting on or off vehicle
7 Standing in road
8 Working in road
9 Playing in road
10 Lying in road
11 Other
12 Not in road
15 VEHICLE MANEUVER
1 Stopped in travel lane
2 Parked out of travel lanes
3 Parked in travel lanes
4 Going straight ahead
5 Changing lanes or merging
6 Passing
7 Making right turn
8 Making left turn
9 Making U turn
10 Backing
11 Slowing or stopping
12 Starting in roadway
13 Parking
14 Leaving parked position
15 Other
16 VEHICLE DEFECTS (List one or more)
1 Defective brakes
2 Defective headlights
3 Defective rear lights
4 Defective steering
5 Defective tires
6 Other defects
7 Not known if defective
8 No defects detected

north carolina

LOCATION

Date of Accident ______ 19 ____ Day of Week ______ Hour ______ AM ☐ PM ☐

Do not write in this space

Accident Occurred In ______ County ☐ In ☐ Near City or Town of ______

Outside City or Town ______ Miles ☐ ☐ ☐ ☐ (N E S W) of ☐ Limits ☐ Center

Patrol Area

On ______ Hwy No (I US NC RP RU) If No or within corporate limits identify by name

☐ Miles ☐ Feet ☐ ☐ ☐ ☐ (N E S W) At or From ______ Hwy No , or Adjacent County Line ______ Toward ______ Hwy No City, or Adjacent County Line

(0 Ft if Intersec)

ACCIDENT TYPE

Ran off Road			Non Collision in Road		Collision of Motor Vehicle in Road With						
1 Right	2 Left	3 Straight Ahead	4 Overturn	5 Other in Road	6 Pedestrian	7 Parked Vehicle	8 Train	9 Bicycle	10 Animal	11 Fixed Obj	12 Other Obj

Collision of M V in Road With Another M V

13 Rear End Slow or Stop	14 Rear End Turn	15 Left Turn Same Roadway	16 Left Turn Cross Traffic	17 Right Turn Same Roadway	18 Right Turn Cross Traffic	19 Head On	20 Sideswipe	21 Angle	22 Backing

TRAFFIC ACCIDENT REPORT

VEHICLE NO 1

No of Vehicles Involved ☐

Driver ______ First ______ Middle ______ Last Name

Address ______

City ______ State ______

Is above address same as on Driver's License? Yes ☐ No ☐

Race/Sex ______ Driver's Lic ______ State ______

Date of Birth ______ Month Day Year ______ Specify Restriction ______

Member of Armed Forces Yes ☐ No ☐ Veh Year ______ Veh Make ______ Veh Type ______

Lic Plate No ______ State ______ Year ______

VIN ______ ODOM ______

Owner ______

Address ______

City ______ State ______

Parts Damaged (TAD) ______ Amount of Damage $ ______

Drivable Yes ☐ No ☐ Vehicle Removed to ______

By ______ Authority ______

Other Property Damaged ______ Amt of Dam. $ ______

VEHICLE NO 2 or PEDESTRIAN

Driver ______ First ______ Middle ______ Last Name

Address ______

City ______ State ______

Is above address same as on Driver's License? Yes ☐ No ☐

Race/Sex ______ Driver's Lic ______ State ______

Date of Birth ______ Month Day Year ______ Specify Restriction ______

Member of Armed Forces Yes ☐ No ☐ Veh Year ______ Veh Make ______ Veh Type ______

Lic Plate No ______ State ______ Year ______

VIN ______ ODOM ______

Owner ______

Address ______

City ______ State ______

Parts Damaged (TAD) ______ Amount of Damage $ ______

Drivable Yes ☐ No ☐ Vehicle Removed to ______

By ______ Authority ______

Owner and Address ______

INJURY SECTION INSTRUCTIONS

Indicate which seats were occupied at the time of the collision, the degree of injury, the type of restraint used, the race, sex and age of the occupants. If occupant not injured you do not need name and address. For type of Restraint (Res.) used N=None L=Lap Belt, LS=Lap & Shoulder, S=Shoulder Belt only

K=Killed	A Incapacitating	B=Nonincapacitating—Injury other than K or A evident at the scene	C=No visible sign of injury but complaint of pain, momentary unconsciousness	O=No injury

SEAT	Inj	Res used	Race sex	Age	INJURED NAMES AND ADDRESSES First Name Last	SEAT	Inj	Res used	Race sex	Age	INJURED NAMES AND ADDRESSES First Name Last
Left Front					DRIVER 1	Left Front					DRIVER 2 OR PEDESTRIAN
Center Front						Center Front					
Right Front						Right Front					
Left Rear						Left Rear					
Center Rear						Center Rear					
Right Rear						Right Rear					
Total No Occupants					Total No Inj	Total No Occupants					Total No Inj

Injured taken to ______

WITNESSES Name ______ Address ______ Phone No ______

Name ______ Address ______ Phone No ______

Arrests Name ______ Charge(s) ______ (Cit No) ______

Name ______ Charge(s) ______ (Cit No) ______

Signature ______ Officer's Rank and Name ______ Number ______ Department ______ Date of Report ______

N C Department of Motor Vehicles DMV-349 (Rev 1-1-73)

ADDED BY ______ (Initial)

MARKS

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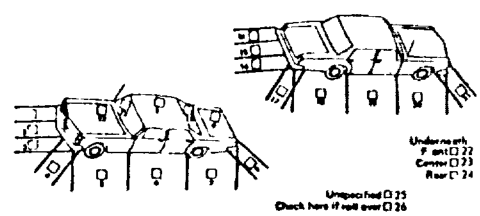
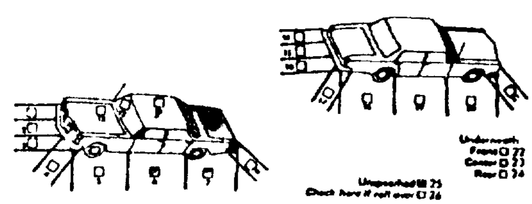
VEHICLE 1 POINT OF INITIAL CONTACT



VEHICLE 2 POINT OF INITIAL CONTACT



1 Locality	9 Traffic Control	Not Operating ☐ - Not Visible ☐			VEHICLE 1	VEHICLE 2
2 Speed Limit	10 Object Struck			15. Veh Maneuver		
3 Road Feature		DRIVER 1	DRIVER 2 or PED	16. Veh Defects		
4. Road Surface	11 Sobriety			17 Estimated Speed		
5. Road Defects	12. Physical Cond			18 Tire Impressions (ft)		
6 Road Condition	13. Chem Test	YES ☐ NO ☐	YES ☐ NO ☐	19 Distance Traveled After Impact (ft.)		
7 Light Condition						
8 Weather	14. Ped Action					

INDICATE NORTH

Vehicle 1 was Traveling ☐ N ☐ E ☐ S ☐ W on

Vehicle 2 was Traveling ☐ N ☐ E ☐ S ☐ W on

DESCRIBE WHAT HAPPENED

Vehicle 1	Vehicle 2	VIOLATION INDICATED
☐	☐	1 No Violation Indicated
☐	☐	2 Excessive Speed
☐	☐	3. Yield Violation
☐	☐	4. Left of Center
☐	☐	5. Passing Violation
☐	☐	6 Stop S. or Yield S. Vio
☐	☐	7 Traffic Signal Vio
☐	☐	8 Safe Movement Vio
☐	☐	9 Too Close
☐	☐	10 Improper Turn
☐	☐	11 Improper or No Signal
☐	☐	12. Improper Parking Location
☐	☐	13. Other Improper Driving

(describe) ______

EMERGENCY ASSISTANCE INFORMATION

INVESTIGATOR NOTIFIED ______ ☐ a.m ☐ p.m
BY ______

INVESTIGATOR ARRIVED ______ ☐ a.m. ☐ p.m

AMBULANCE ARRIVED ______ ☐ a.m ☐ p.m

OTHER COMMENTS ______

RESERVED FOR STATE USE

20	21	22	23	24
25	26	27	28	29

RESERVED FOR CITY OR OTHER USE

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SOUTH CAROLINA
UNIFORM TRAFFIC COLLISION REPORT

SOUTH CAROLINA
STATE HIGHWAY DEPARTMENT
COLUMBIA
Form TR 310 Rev 3 72

(FOR INVESTIGATING OFFICERS)

MAIL REPORTS TO STATE HIGHWAY DEPARTMENT COLUMBIA S C 29202

Sheet ____ of ____ Sheet(s)

south carolina

TOTAL NO VEHICLES

COLLISION INVOLVED (CIRCLE ONE OR MORE)
1 – SINGLE MOTOR VEHICLE 4 – PEDESTRIAN 7 – TWO OR MORE MOTOR VEHICLES 0 – FIXED OBJECT ______
2 – OVERTURNED IN ROAD 5 – BICYCLE 8 – RAN OFF ROAD & OVERTURNED ___ IN ROADWAY OR
3 – RAN OFF ROAD 6 – MOTORCYCLE 9 – OTHER ______ ___ ft FROM PAVEMENT EDGE

LOC & TIME

DATE / / | COUNTY | DAY OF WEEK S M T W T F S | TIME : AM PM | **ON** 1 – INTERSTATE 2 – U S PRIMARY 3 – S C PRIMARY 4 – SECONDARY 5 – COUNTY 6 – OTHER | ROUTE OR ROAD NUMBER AND S+ Name if Any | MILE POST

AT INTERSECTION OF ROUTE OR ROAD NUMBER (And Street if Any) | IF NOT AT INTERSECTION 1 – FEET 2 – MILES N E S W OF | ROUTE OR ROAD NUMBER And Street Name if Any

IN CITY OR TOWN | CONTROLLED ACCESS HIGHWAY LOCATION (Circle One) 1 – MAIN ROAD 2 – FRONTAGE RD 3 – MAIN ROAD AT INTERCHANGE 4 – ENTRANCE RAMP 5 – EXIT RAMP | N E S W 1 – BOUND LANE 2 – SIDE

IF OUTSIDE CITY LIMITS ____ MILES N E S W OF CITY OR TOWN

UNIT #1

DRIVER

DRIVER'S FULL NAME | STREET OR R F D | CITY AND STATE | ZIP | DATE OF BIRTH | SEX | RACE

DRIVER LICENSE NUMBER | STATE | **TYPE** 1 – AUTO 2 – REG TRUCK 3 – MOTORCYCLE 4 – OTHER TRUCK 5 – BEGINNER 6 – NONE | LICENSE RESTRICTION | RESTRICTION COMPLIED WITH Y – YES N – NO

OCCUPATION | MEMBER OF ARMED FORCES Y – YES N – NO | **DRIVER CONDITION** (CIRCLE ONE) 1 – NO APPARENT DEFECTS 2 – APPARENTLY ASLEEP 3 – ILL 4 – FATIGUED 5 – BODY DEFECT ______ 6 – UNKNOWN

DRIVER SOBRIETY HAD BEEN DRINKING OR USING DRUGS Y – YES N – NO U – UNKNOWN | TYPE TEST GIVEN | TEST RESULTS 1 – POS 2 – NEG | REFUSED TEST Y – YES N – NO | MOVING VIOLATION(S) INDICATED

VEHICLE

MAKE & IDENTIFICATION (SERIAL) NO | BODY | YR MK | **INSPECTION CERTIFICATE** 1 – CURRENT 2 – EXPIRED 3 – NONE 4 – UNKNOWN | LICENSE TAG NUMBER | STATE | YEAR

OWNER'S NAME | STREET OR R F D | CITY AND STATE | ZIP | SPEED LIMIT MPH | ESTIMATED SPEED MPH

TYPE (CIRCLE ONE) 01 – AUTO 02 – BICYCLE 03 – STA WAGON 04 – PANEL PICKUP 05 – TR TRACTOR 06 – OTHER TRUCK 07 – FARM MACH 08 – COMM BUS 09 – SCHOOL BUS 10 – OTHER BUS 11 – M CYCLE 12 – OTHER ______ Safety Equip Used Y – Yes N – No

SPECIAL USE (CIRCLE ONE) 01 – NONE 02 – TAXI 03 – MILITARY 04 – CONSTRUCTION 05 – AMBULANCE 06 – FARM USE 07 – POLICE 08 – WRECKER 09 – GOVERNMENT 10 – FIRE FIGHTING 11 – DRIVER TRAINING 12 – OTHER ______

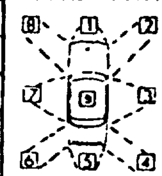
ATTACHMENT (CIRCLE ONE) 1 – NONE 2 – MOBILE HOME 3 – SEMI TRAILER 4 – UTILITY TRAILER 5 – FARM TRAILER 6 – TRAILER WITH BOAT 7 – CAMPER TRAILER 8 – TOWED MOTOR VEH 9 – PETROLEUM TANKER 0 – OTHER ______

DEFECTS (CIRCLE ONE OR MORE) 1 – NONE 2 – BRAKES 3 – LIGHTS 4 – HORN 5 – STEERING 6 – WIPERS 7 – TURN SIGNALS 8 – TIRES 9 – OTHER ______ 0 – NOT KNOWN | DEFECT CONTRIBUTED TO CRASH Y – YES N – NO

DAMAGE SEVERITY 1 – SLIGHT 2 – MODERATE 3 – SEVERE | AREA(S) DAMAGED (Use Codes) | APPROXIMATE COST TO REPAIR $ ______ | VEHICLE TOWED AWAY Y – YES N – NO

VEHICLE TOWED BY WHOM | TO WHERE | TOTAL OCCUPANTS THIS UNIT ______

CIRCLE POINT OF INITIAL IMPACT



UNIT #2 OR PEDESTRIAN

DRIVER

DRIVER'S OR PEDESTRIAN'S NAME | STREET OR R F D | CITY AND STATE | ZIP | DATE OF BIRTH | SEX | RACE

DRIVER LICENSE NUMBER | STATE | **TYPE** 1 – AUTO 2 – REG TRUCK 3 – MOTORCYCLE 4 – OTHER TRUCK 5 – BEGINNER 6 – NONE | LICENSE RESTRICTION | RESTRICTION COMPLIED WITH Y – YES N – NO

OCCUPATION | MEMBER OF ARMED FORCES Y – YES N – NO | DRIVER or PED **CONDITION** 1 – NO APPARENT DEFECTS 2 – APPARENTLY ASLEEP 3 – ILL 4 – FATIGUED 5 – BODY DEFECT ______ 6 – UNKNOWN

DRIVER or PED **SOBRIETY** HAD BEEN DRINKING OR USING DRUGS Y – YES N – NO U – UNKNOWN | TYPE TEST GIVEN | TEST RESULTS 1 – POS 2 – NEG | REFUSED TEST Y – YES N – NO | MOVING VIOLATION(S) INDICATED

VEHICLE

MAKE & IDENTIFICATION (SERIAL) NO | BODY | YR MK | **INSPECTION CERTIFICATE** 1 – CURRENT 2 – EXPIRED 3 – NONE 4 – UNKNOWN | LICENSE TAG NUMBER | STATE | YEAR

OWNER'S NAME | STREET OR R F D | CITY AND STATE | ZIP | SPEED LIMIT MPH | ESTIMATED SPEED MPH

TYPE (CIRCLE ONE) 01 – AUTO 02 – BICYCLE 03 – STA WAGON 04 – PANEL PICKUP 05 – TR TRACTOR 06 – OTHER TRUCK 07 – FARM MACH 08 – COMM BUS 09 – SCHOOL BUS 10 – OTHER BUS 11 – M CYCLE 12 – OTHER ______ Safety Equip Used Y – Yes N – No

SPECIAL USE (CIRCLE ONE) 01 – NONE 02 – TAXI 03 – MILITARY 04 – CONSTRUCTION 05 – AMBULANCE 06 – FARM USE 07 – POLICE 08 – WRECKER 09 – GOVERNMENT 10 – FIRE FIGHTING 11 – DRIVER TRAINING 12 – OTHER ______

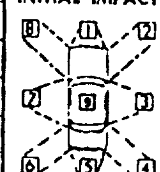
ATTACHMENT (CIRCLE ONE) 1 – NONE 2 – MOBILE HOME 3 – SEMI TRAILER 4 – UTILITY TRAILER 5 – FARM TRAILER 6 – TRAILER WITH BOAT 7 – CAMPER TRAILER 8 – TOWED MOTOR VEH 9 – PETROLEUM TANKER 0 – OTHER ______

DEFECTS (CIRCLE ONE OR MORE) 1 – NONE 2 – BRAKES 3 – LIGHTS 4 – HORN 5 – STEERING 6 – WIPERS 7 – TURN SIGNALS 8 – TIRES 9 – OTHER ______ 0 – NOT KNOWN | DEFECT CONTRIBUTED TO CRASH Y – YES N – NO

DAMAGE SEVERITY: 1 – SLIGHT 2 – MODERATE 3 – SEVERE | AREA(S) DAMAGED (Use Codes) | APPROXIMATE COST TO REPAIR $ ______ | VEHICLE TOWED AWAY Y – YES N – NO

VEHICLE TOWED BY WHOM | TO WHERE | TOTAL OCCUPANTS THIS UNIT ______

CIRCLE POINT OF INITIAL IMPACT



INTENT

DRIVER INTENTIONS

1	2		1	2		1	2		1	2		1	2	
01	01	GO STRAIGHT AHEAD	04	04	REMAIN STOPPED IN LANE	07	07	REMAIN PARKED – LEGALLY	10	10	TURN RIGHT	13	13	U TURN
02	02	SLOW OR STOP	05	05	PASS	08	08	REMAIN PARKED – ILLEGALLY	11	11	TURN LEFT	14	14	MERGE
03	03	START IN TRAFFIC LANE	06	06	START FROM PARKED	09	09	OTHER ______	12	12	BACK	15	15	PARK

PEDESTRIAN ACTIONS

(CLOTHING 1 – DARK 2 – LIGHT & ROAD 1 – DARK 2 – LIGHT)

01 – CROSSING OR ENTERING INTERSECTION
02 – CROSSING OR ENTERING OTHER
03 – WALKING IN RDWY WITH TRAFFIC
04 – WALKING IN RDWY AGAINST TRAFFIC
05 – STANDING IN RDWY
06 – GETTING ON OR OFF VEHICLE
07 – PUSHING OR WORKING ON VEHICLE
08 – OTHER WORKING IN RDWY
09 – PLAYING IN RDWY
10 – OTHER IN RDWY
11 – NOT IN RDWY
12 – OTHER

DAMAGE TO PROPERTY OTHER THAN VEHICLE (Name Owner, State Object and Damage) | APPROX COST TO REPAIR $______

WIT.

WITNESS FULL NAME | ADDRESS | AGE | SEX

WITNESS FULL NAME | ADDRESS | AGE | SEX

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CODES

SEATING	SEAT BELTS	EJECTION	INJURY	FIRST AID BY
1 2 3 / 4 5 6 / 7 8 9; P—Pedestrian; M—Motorcycle; B—Bicycle; O—Other; U—Unknown	LAP BELT ONLY: N—None Installed; F—Fastened; U—Unfastened; D—Not reported. LAP & SHOULDER BELT: E—Not used; G—Lap belt only used; H—Both belts used; L—Not reported	Y—Yes; P—Partially; N—No; U—Unknown	K—Killed; A—Visible signs of injury as bleeding wound or distorted member or had to be carried from scene; B—Other visible injury as bruises, abrasions, swelling, limping, etc.; C—No visible injury but complaint of pain or momentary unconsciousness	P—Police; A—Amb. Attend; D—Doctor; O—Other; U—Unknown; N—None

VICTIMS

			AGE	SEX	VEH NO	SEAT NO	SEAT BELTS	EJECTION	INJURY	FIRST AID BY
1	NAME	ADDRESS								
	TAKEN TO	TAKEN BY								
2	NAME	ADDRESS								
	TAKEN TO	TAKEN BY								
3	NAME	ADDRESS								
	TAKEN TO	TAKEN BY								
4	NAME	ADDRESS								
	TAKEN TO	TAKEN BY								

NARRATIVE & DIAGRAM

DIAGRAM WHAT HAPPENED

INSTRUCTIONS

1. Follow dotted lines to draw outline of roadway at place of accident
2. Number each vehicle and show direction of travel by arrow
3. Use solid line to show path before accident; dotted line after accident
4. Show pedestrian by
5. Show railroad by
6. Show utility poles by
7. Show motorcycle by

INDICATE NORTH

Direction of Travel	N	E	S	W
Vehicle 1	1	2	3	4
Vehicle 2	1	2	3	4

DESCRIBE WHAT HAPPENED (Refer to vehicles by number):

ROADWAY & ENVIRONMENT

LIGHT (Circle One)
1 – DAYLIGHT
2 – DAWN
3 – DUSK
4 – DARKNESS
5 – DARKNESS RD LIGHTED

WEATHER (Circle One)
1 – CLEAR
2 – RAINING
3 – FOG
4 – SNOWING SLEETING
5 – HAILING

LOCALE (Circle One)
1 – OPEN COUNTRY
2 – RESIDENTIAL
3 – SHOPPING or BUSINESS
4 – MFG. or INDUSTRIAL
5 – SCHOOL or PLAYGD
6 – ______

CHARACTER (Circle One)
1 – STRAIGHT LEVEL
2 – STRAIGHT ON GRADE
3 – STRAIGHT HILLCREST
4 – CURVE LEVEL
5 – CURVE ON GRADE
6 – CURVE HILLCREST

CONSTRUCTION (Circle One)
1 – ASPHALT
2 – CONCRETE
3 – BRICK
4 – DIRT

CONDITION (Circle One)
1 – DRY
2 – WET
3 – SNOWY ICY
4 – MUDDY
5 – HAZARDOUS MATERIAL

VISION OBSCURED (Circle One For Each Veh.)
1 2
01 01 – NOT OBSCURED
02 02 – RAIN SNOW ICE Etc. ON WINDSHIELD
03 03 – TREES, CROPS, BUSHES, Etc.
04 04 – BUILDING(S)
05 05 – EMBANKMENT
06 06 – SIGNBOARD
07 07 – HILLCREST
08 08 – PARKED VEHICLE(S)
09 09 – MOVING VEHICLE(S)
10 10 – BLINDED BY HEADLIGHTS
11 11 – BLINDED BY SUNLIGHT
12 12 – OTHER ______
13 13 – UNKNOWN IF OBSCURED

DEFECTS (Circle One or More)
1 – SHOULDERS LOW
2 – SHOULDERS HIGH
3 – HOLES, BUMPS, Etc.
4 – LOOSE MATERIAL ON SURFACES
5 – ROAD UNDER CONST.
6 – NONE
7 – OTHER ______

TRAFFIC CONTROL (Circle One & Yes or No)
1 – STOP SIGN
2 – STOP & GO SIGNAL
3 – YIELD SIGN
4 – OFFICER OR FLAGMAN
5 – RR CROSSING GATES
6 – RR FLASHING LIGHTS
7 – NONE
8 – OTHER ______
FUNCTIONING Y – Yes N – No

ROADWAY LANES (Circle Two)
ONE WAY STREET Y – Yes N – No
1 – ONE LANE
2 – TWO LANES
3 – THREE LANES
4 – FOUR LANES
5 – FIVE LANES
6 – SIX LANES OR MORE
7 – UNPAVED (ANY WIDTH)

ROADWAY DIVIDED BY (Circle One)
1 – GUARDRAIL
2 – CONCRETE MEDIAN
3 – EARTH MEDIAN
4 – ROUGH MEDIAN
5 – PAINTED MEDIAN OF 3 FT. WIDE OR MORE
6 – OTHER
7 – NO DIVISION

INVESTIGATION

SUMMONS NUMBER — NAME OF PERSON CHARGED — MOVING VIOLATION CODES

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TIME POLICE NOTIFIED A.M. P.M.	POLICE ARRIVED A.M. P.M.	AMBULANCE ARRIVED A.M. P.M.	PHOTOS TAKEN BY OFFICER Y – YES N – NO	TRAFFIC FLOW RESTORED A.M. P.M.

NAME OF REPORTING OFFICER — BADGE NUMBER — POLICE AGENCY

NAME OF OTHER OFFICER THIS AT SCENE — BADGE NUMBER — POLICE AGENCY

I CERTIFY THAT THIS REPORT REFLECTS MY BEST KNOWLEDGE, OPINION AND BELIEF CONCERNING THE ACCIDENT BUT NO WARRANTY IS MADE AS TO THE FACTUAL ACCURACY THEREOF

SIGNATURE OF REPORTING OFFICER — DATE / /

MOVING VIOLATION CODES

00 No Improper Driving
01 Violations Unknown
11 Improper Backing
22 Shifting Lanes Improperly
23 Parking Improperly
25 Failure to Dim Lights
26 Lights Improper
28 Veh. Unsafe Cond.
29 Driving in Wrong Lane
4A No Sig. Imp. Sig.
4B Following too closely
4C Defective Brake
41 Over 21 Speeding
42 Disregard Sign Sig.
44 No Right of Way
45 Wrong Side of Road
46 Passing Unlawfully
47 Turning Unlawfully
48 Driving in Safety Zone
61 Reckless Driving
62 Pass Stpd School Bus
63 Hit & Run Prop. Dam.
82 Other Moving Viol.
83 Exc. Wt. Ht. Lt. Wh.
84 Pedestrian Drunk
92 Faulty Equipment
93 Walking Violation
97 Min. Speed Law
98 Racing on Hwy.
99 Driving under Inf.

Original size of document – 8 1/2 x 11